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# A REVISION OF THE NORTH AMERICAN PACHYGASTERINÆ WITH UNSPINED SCUTELLUM (DIPTERA).

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It is not by any means unusual for taxonomic workers in entomology to discover, when classifying genera in families which consist of a large number of closely allied species that characters which they find of considerable value for their purpose, and which apparently are of real generic rank in these groups, are found not in a number of species, but in individual species in other portions of their series. Indeed, the systematist almost invariably finds that by a consistent application of the test of his separating characters throughout a family he has several large groups of species set apart from each other, collectively, by characters the use of which in classifying a certain residue of species—often more closely related biologically than are some of the individuals of the seemingly natural groups which his application of certain rules has defined—will result in a generic separation giving a single species to each genus. I have had this experience in almost every family of insects that I have studied, but have no remedy to suggest, since without a knowledge of the life history of the species we are often unable to decide upon the limits of genera except arbitrarily, or—which amounts to the same thing—by a consideration of structural details of the adults. In every order, differences of opinion exist regarding the status of genera, and still more commonly in the case of species, and, apart from

those differences which arise between taxonomists because of their personal relations, it is often impossible to decide which is the correct attitude regarding certain disputed points.

It has been my task lately to identify certain species of Stratiomyiidæ contained in the collection of the Illinois State Laboratory of Natural History, and in doing this I have been confronted with a situation such as I have briefly outlined above. It is not my intention to deal with species other than those included in that group of the subfamily Pachygasterinæ which has the scutellum without distinct thorns, although mention is made of certain analogous cases in other genera.

In addition to the taxonomic details given herein, I have summarized such biological data as I have been able to obtain.

The genus *Pachygaster* Meigen has been subdivide by Austen (*Neopachygaster*), Coquillett (*Zabrachia*), and Kertesz (*Eupachygaster*), or at least species considered by other authors as belonging to *Pachygaster* sens. lat., have been removed to other genera by the authors just mentioned. Austen erected the genus *Neopachygaster** to receive *Pachygaster meromelaena* Perris, considered by Verrall† as synonymous with *P. orbitalis*. Austen distinguished this genus from *Pachygaster* by the separated eyes in the male and the fact that the posterior orbits are not produced in the form of a prominent ridge in either sex. It is, to my mind, a weakly defined genus, and it has been rejected by Verrall in the work already referred to. Whether it is expedient to retain it is a point upon which there is ground for diversity of opinion. Coquillett erected the genus *Zabrachia*‡ for the reception of a species which he described under the name *polita*. This genus he distinguished from *Pachygaster* and its allies by the simple third vein. Though uncertain as to whether the species is or is not synonymous with *Pachygaster minutissimus* Zetterstedt, I am inclined to the opinion that they are identical; but in the absence of European examples of the latter I refrain from expressing a decided opinion. It is, however, pertinent to point out that Kertesz has placed *minutissimus* in *Zabrachia* in a recent paper on the genera, and that English writers have suggested that the species

*Ent. Monthly Mag., Vol. 37, 1901, p. 245.
†*British Flies*, Vol. 5, 1909, pp. 66 and 75.
‡Bull. 47 N. Y. State Mus., 1901, p. 585.

might be considered as generically distinct from both *Pachygaster* and *Neopachygaster*. Dr. Sharp's suggestion to this effect is disposed of by Verrall in dealing with *Neopachygaster*, and in his notes under *P. tarsalis* he mentions a specimen of that species which has the fork of the third vein "so indistinct as to be almost absent." In this connection it seems reasonable to indicate that in several genera in this family the absence or presence of the fork of the third vein is not considered as of more than specific value. This is noticeably true in *Nemotelus* and *Oxycera*, where one finds that even in recent papers the presence or absence of the fork is not used even as a primary key character for the species. To be consistent, one who accepts this character as of generic value in Pachygasterinæ would almost as certainly be required to accept it as such in the other subfamilies; or, conversely, since this character is considered as of specific value only in genera which contain a much larger number of species than does *Pachygaster* sens lat., it is inconsistent to accept it as of generic value in the latter.

There is, however, a slight but fundamental difference between *Zabrachia* and such genera as *Nemotelus* and *Oxycera*, the two latter having the third vein differently formed. In this connection see notes on *Zabrachia*.

The structure of the head of the male, in which the eyes are distinctly separated, is the only character of importance in the separation of *Neopachygaster* from *Pachygaster*, which latter has the eyes of the male contiguous, and it is practically impossible for any one but an expert to separate the females of the genera.

The last subdivision of the old genus is that of Kertesz, referred to in a subsequent part of the present paper, by which the genus *Eupachygaster* was erected to receive *Pachygaster tarsalis* Zetterstedt.

I have drawn up a key to the genera of North American *Pachygasterinæ* as limited in the heading to this paper, which should make the situation clear.

KEY TO PACHYGASTERINAE WITH UNARMED SCUTELLUM.

1. Third vein simple....2
   Third vein furcate....3
2. Third (complex) antennal joint elongate....*Berkshiria*
   Third antennal joint short, disclike or slightly reniform....*Zabrachia*
3. Arista subplumose, slender; third antennal joint round; eyes of male contiguous *Lophoteles*
   Arista densely or slightly pubescent, or bare, rarely slightly thickened; third antennal joint elongate or disclike; eyes of male contiguous or distinctly separated....4
4. Scutellum directed upward, triangular, terminating in a short obtuse process.5
   Scutellum regularly rounded apically, or with a distinct transverse suture or depression before the apex which gives to the scutellum the appearance of having a raised post-marginal rim....6
5. Third antennal joint disclike, arista longer than entire antenna; eyes of male narrowly separated....*Eucynipimorpha*
   Third antennal joint elongated, arista shorter than antenna; eyes of male contiguous .... *Cynipimorpha**
6. Third antennal joint elongate; eyes of male contiguous above antennæ, the facets slightly decreasing in size as they near lower margin but without any sharp line of division; scutellum with distinct marginal rim or ridge.. *Johnsonomyia*
   Third antennal joint disclike....7
7. Eyes of male contiguous; antennæ in both sexes inserted distinctly below middle of profile....*Pachygaster*
   Eyes of male separated; antennæ in both sexes inserted at or near middle of head in profile....8
8. Scutellum much swollen, and with a distinct rim, the margin with a number of small wartlike protuberances; frons with a distinct incised median line from anterior ocellus to middle....*Eupachygaster*
   Scutellum slightly swollen, with a slightly defined rounded margin which is not armed with protuberances; frons without median incised line from anterior ocellus to middle....*Neopachygaster*

## **Berkshiria** Johnson.

This genus was erected for the reception of a single species, *albistylum* Johnson.†

The locality of the species is Austen's Brook, Chester, Mass., collected May 28, 1912, by C. W. Johnson.

The following is a copy of the original description.

"BERKSHIRIA gen. nov."

"Third joint of the antennæ oblong, about double the length of the first and second taken together; third joint with five annuli, the basal one broader than the others; arista terminal, style-like, about as long as the entire antenna; front with two longitudinal ridges; transverse suture deeply impressed; scutellum large, rounded, with a broad depressed margin; third longitudinal vein without the anterior branch; ends of the terminal joints of the tarsi with bristle-like hairs. Type *B. albistylum* sp. nov."

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*See under *Eucynipimorpha*.

†*Psyche*, Vol. 22, 1914, p. 158.

"*Berkshiria albistylum* sp. nov."

"Black; front shining, the two ridges forming deep central and orbital grooves, ocelligerous tubercle prominent; face receding, the orbits white; antenna yellow, arista white with its basal fourth black. Thorax sparsely covered with a whitish pubescence; humeri angulate with a small yellow spot at each point, a raised collar extending between the humeri, and a blunt spine on each side before the base of the wing. Abdomen broad, about double the width of the thorax, the five segments shining, sparsely covered with whitish hairs. Halteres white, base of the knobs and stems brown. Legs black, knees, tips of the tibiæ and the tarsi yellow, the last two joints of the latter brownish. Wings hyaline, veins yellowish, three veins extending from the discal cell. Length, 4 mm."

I have not seen the species. Except in the absence of the fork of the third vein it must very closely resemble *Johnsonomyia aldrichi*, described in the present paper.

Nothing is known of the early stages, and no indication of the sex of the type is given in the description.

**Zabrachia** Coquillett.

This genus was erected for the reception of a single species, *polita* Coquillett.* It is distinguished from all other North American genera of this group of the subfamily except *Berkshiria* by the absence of the fork of the third vein. From *Berkshiria* it is distinguished by the structure of the antennae, those of *Zabrachia* being short and the third joint disc-like, while in *Berkshiria* they are elongated, and the third joint noticeably longer than broad.

**Zabrachia polita** Coquillett.

*Male.*—Glossy black. Antennæ yellow, arista brown. Legs yellow, coxæ and femora black, apices of latter yellow. Wings clear, veins grayish. Halteres black.

Head in profile (Fig. 3) slightly higher than long, eyes covering the entire side, ocellar region slightly raised; eyes bare, contiguous above, leaving only the ocellar and supra-antennal triangles visible, upper eye-facets distinctly larger than lower, separated by a distinct transverse line slightly above base of antennæ; antennæ short, complex joint disclike; arista short, bare, and hairlike; proboscis of moderate size. Mesonotum finely and rather closely punctured, surface hairs very short, dark; scutellum with disc as that of mesonotum, a distinct depression near margin, giving it the appearance of having a marginal rim, the base appreciably swollen, the whole in profile with an upward

*Bull. 47, N. Y. State Mus., 1901, p. 585.

direction. Abdomen more glossy than mesonotum and without distinct punctures, the surface hairs sparse and slightly longer than those of thorax. Legs slender. Third vein ending as far before apex of wing as its own length; distance from apex of stigma to apex of third vein slightly longer than the preceding section of costa; apex of discal cell very slightly proximad of apex of stigma (Fig. 6).

*Female.*—Differs in color from the male only in having the halteres yellow.

Structurally, the head differs from that of the male more than in other genera dealt with in this paper. The frons is broad, over one third the head-width, raised, with a central incised line which broadens above antennæ, giving the frons the appearance of having a raised, rounded ridge on each side; postocular orbits prominent, visible from vertex to lower margin; cheeks distinct; eyes much smaller than in the male, facets of equal size throughout; profile as Figure 4. Thorax as in male, the scutellum with less noticeable rim.

Length, 2.5–3 mm.

Originally described from Saranac Inn, N. Y. Subsequently recorded by C. W. Johnson as having been reared from larvae found under the bark of pine logs at Auburndale, Mass., March 26, 1905.* The imagines emerged between May 12 and June 20. Two specimens kindly submitted by Mr. Johnson bear the date of May 18, 1905. One of the specimens has the empty pupal skin attached to the pin, and is figured herewith (Figs. 9 and 10).

Comparison of the pupa of this specimen with those figured by Verrall and here reproduced shows that while they are similar in general appearance, they may be separated by the disposition and length of the bristles. (See Figs. 11 and 12).

I have a suspicion that this species may be synonymous with *minutissima* Zetterstedt, a European species which has been reared from larvæ found under bark of pine trees, but Verrall's description† gives the eyes of the male as longer than deep, which is not the case with the specimens before me. I have no European examples for comparison, so leave the matter as it is for the present. It is pertinent to remark, however, that Verrall in his notes of the species indicates that the head of the only English male specimen he had seen is quite as deep as long—at variance with his description. Dr. D. Sharp has reared *minutissimus* from larvæ found under bark of *Pinus sylvestris* at Nethy Bridge, Scotland. The species is found in Scandinavia, France, Denmark, Austria and Germany,

*Psyche*, Vol. 13, 1906, p. 3.

†*British Flies*, Stratomyidæ, Vol. 5, p. 67.

and is associated with *Abies* and *Pinus*. Perris reared it from larvæ found on *Pinus maritimus* in the burrows of *Tomicus* and *Hylurgus*, and gives a full description of the stages, with figures,* under the name *Pachygaster pini* Perris.

Verrall's contention that this genus is not a valid one because of the possibility of the fork of the third vein becoming obsolete in occasional specimens of other species which ought to have it present can not be entertained, as the course of the veins in *Zabrachia* precludes the possibility of its ever being furcate, and is quite a different case from that of the other genera cited.

**Lophoteles** Loew.†

The type spécies of this genus was described from specimens taken on the Polynesian island of Radak. Subsequently Williston described a species, *pallidipennis*, from Atoyac, Vera Cruz, Mexico, which he considered congeneric.‡ I have some doubt as to the generic position of Williston's species, which I have not seen. The description of the antenna is not clear enough to permit one's forming an opinion as to its structure, but the fact that the arista is densely plumose is demonstrated both in the description and in the figure. A copy of Williston's description is given below. Williston was not certain of the sex of his specimen.

*Lophoteles pallidipennis.*

"*Female.*—Head black, covered with whitish dust, with the exception of a slender median line and the lowermost portion, which are shining. At the vertex the eyes are separated by the ocelli, the front gradually widening anteriorly. Antennæ black, the first two joints yellow; arista densely pubsecent, appearing almost like a solid mass, in length equal to about twice that of the first three joints together. Thorax deep black, moderately shining, the color mostly concealed beneath silvery tomentum, which is arranged in slender stripes, leaving the black color apparent between them. Scutellum subtriangular, the middle portion of the margin produced into a thin edge, upon which a number of minute points are visible; the basal part uniformly and thickly silvery-tomentose, the apical portion opaque black. Abdomen black, for the most part concealed beneath a dense silvery tomentum. Legs light yellow; all the femora, except their tip, black. Wings hyaline, the veins yellow and not at all stout. Length 3½ millim."

*Ann. Soc. Ent. France, 1870, p. 210.
†Berl. Ent. Zeitschr., 1858, p. 110.
‡Biol. Centr. Amer., Diptera, Vol. I, 1901, p. 250.

**Eucynipimorpha,** n. gen.

This genus is erected for the reception of the species described by Williston as *Cynipimorpha minuta*. It differs from *bilimeki* in the form of the antennæ. In *Cynipimorpha** the antennæ are elongate, the third joint exceeding in length that of the first and second combined; the second joint is produced, thumb-like, on the upper inner side, and the arista is slender, not longer than third joint, and bare. In *minuta* the antennæ are short, and the third joint is transversely ellipsoidal, and the arista very slender and distinctly longer than the entire antenna. The eyes of the male of *C. bilimeki* are contiguous, while those of *minuta* are narrowly separated. Kertesz has pointed out the differences between the species and suggested that *minuta* is probably a new genus.†

Type of genus, *Cynipimorpha minuta*.‡

Williston's description of *minuta* is as follows:

"*Male.*—Eyes separated by the ocelli, gradually becoming wider below; ocelli situated upon a tubercle, otherwise the front is plane. First two joints of the antennæ very short; third joint transversely ellipsoidal, finely roughened, with the very slender arista springing from the upper front part. Face silvery-white, not at all projecting in profile; the oral opening extends to the root of the antennæ, which arise from near the middle of the head, as seen in profile. Thorax wholly black; mesonotum in the middle clothed with dense, short, silvery pubescence, somewhat variable in different reflections, the sides with a patch of sparse, coarser, silvery tomentum. Knob of the halteres white. Abdomen black, moderately shining, broader than the thorax and only a little longer than wide; near the tip with some sparse white pile. Legs light yellow; the femora, except the tip, nearly black. Wings hyaline, neuration as described for *C. bilimeki*, Brauer. Scutellum triangular, obtusely pointed, the basal portion with white pubescence. Length 2½ millim."

Kertesz's genus *Lyprotemyia*§ is closely allied to both *Cynipimorpha* and *Eucinypimorpha*, differing from the former in having the antennæ stout and the third joint disc-like, as well as in other respects. From *Eucynipomorpha* it is distinguished by the elongated head, which is distinctly longer than high; the slender thorax; very erect, almost vertical,

*See Brauer, Die Zweifl. des Kaiserl., Mus. zu Wien, Vol. 44, 1882, p. 75.
†Ann. Mus. Nat. Hung., Vol. 5, 1908, p. 344.
‡Biol. Cent. Amer., Diptera, Vol. 1, p. 252.
§Ann. Nat. Mus. Hung., Vol. 6, 1909, p. 391.

thornlike scutellum; the basally constricted abdomen; and the very slender legs. The general habitus of the species *formicæformis* is entirely different from that of the two other genera under discussion.

The known distribution of the three genera is as follows:

*Eucynipimorpha minuta* Williston, Chilpancingo in Guerrero, Mexico.

*Cynipimorpha bilimeki* Brauer, Cuernavca, Orizaba, Mexico.

*Lyprotemyia formicæformis* Kertez, Meshagua, Urubambafluss, Peru.

Nothing is known of the life history of any of the genera.

**Johnsonomyia,** n. gen.

*Male.*—Eyes contiguous; ocelli on a raised knob; antennæ elongate, flagellum distinctly longer than broad, arista apical, densely short-haired, insertion of antennæ slightly above middle of head in profile; orbits indistinguishable in profile. Scutellum similar to that of *Eupachygaster*. Abdomen short and broad. Apex of stigma proximad of apex of discal cell; third vein forked; discal cell emitting three veins.

*Female.*—Eyes widely separated above; antennæ rather larger than in male, and arista more conspicuously haired.

Type of genus, *Johnsonomyia aldrichi* n. sp.

**Johnsonomyia aldrichi,** n. sp.

*Male.*—Black, shining. Antennæ dark brown, basal two joints of flagellum yellow; arista white, blackish at base; frontal triangle black, with a small silvery pilose spot on each side below; a silvery line extending along eye margin from base of antennæ to posterior orbits; face glossy black; proboscis brownish; hairs on vertex and lower portion of head black. Hairs on thorax black, those on disc appearing slightly brownish when viewed at certain angles. Hairs on abdomen white. Legs blackish-brown, knees, apices of tibiæ, and basal four joints of tarsi yellow. Wings clear, veins yellow. Halteres black, knob grayish brown.

Frontal triangle very small; eyes touching, facets becoming slightly smaller on lower half; antennal flagellum consisting of five joints, arista densely clothed with short hairs; sides of face and the cheeks diverging below; profile as in figure 15. Hairs on disc of mesonotum upright and of moderate length, those on scutellum shorter and very closely placed; thoracic suture very distinct on disc, forming 2 rather conspicuous cavities which run diagonally backward to middle of mesonotum and do not join, being narrowly separated on the median line; outline of scutellum very much like that of *Eupachygaster punctifer*, differing in having the apical production slightly upcurved and the small marginal thorns (4) confined to the apex (Fig. 5). Segments of abdomen closely fused, the divisions hardly perceptible; surface with short decumbent

hairs, each of which is situated in a shallow puncture. Legs normal in form. Venation as in Figure 6 except that the third vein is more elongate and furcate.

Length, 2.5 mm.

*Female.*—Differs from the male in having the antennæ and the legs, especially the tarsi, paler, and the halteres yellow.

Eyes separated by one-third the head-width; frons with three distinct longitudinal grooves, the central one deep and broad, the lateral pair shallow; ocellar region humplike; antennæ noticeably larger than in male; face and frons, in profile, receding at about the same angle from base of antennæ; posterior orbits narrow; profile as in Figure 14. In other respects as the male.

Length, 3.5 mm.

Type locality, Lafayette, Ind., July 18, 1913 (J. M. Aldrich).

Allotype locality, Victoria, Texas, April 9, 1914, Bishopp No. 3266; submitted by Prof. J. M. Aldrich from material belonging to the U. S. Bureau of Entomology.

I have named the genus in honor of Mr. C. W. Johnson, who has done much good work on Stratiomyiidæ, as well as on other families, and the species in honor of the collector, whose efforts resulted in my obtaining for examination the paratype material of *Pachygaster* from the Loew collection in Cambridge, Mass.

Nothing is known of the early stages of this species.

**Pachygaster** Meigen.*

The genus *Pachygaster* has as its type *atra* Meigen, and as at present limited includes one North American species, *pulcher* Loew. The eyes of the male are contiguous above for a considerable distance, the antennæ are short, the third joint disc-like, the scutellum is without a distinct rim, unspined, and not noticeably swollen, and the third vein is furcate. The female bears a closer resemblance to that of *Zabrachia* than to *Neopachygaster*, but the furcate third vein readily separates it from the former, while the difference in the profile of the head separates it from the latter. The structure of the head of *pulcher* differs considerably from that of *atra*, as is shown by Verrall's figure, but I consider the difference insufficient to warrant their generic separation.

*Illig. Mag., Vol. 2, 1803, p. 266.

**Pachygaster pulcher** Loew.*

*Male.*—Glossy black. Antennæ yellow; face with a white pilose line on each side, eyes with three narrow lines across center. Disc of mesonotum with short dark upright hairs. Abdomen shining, a large portion of the disc opaque. Legs yellow, coxæ, and femora except bases and apices blackened. Wings slightly infuscated, especially along the fore margin on basal half, veins brown. Halteres yellow, usually with a dark spot on outer under surface of knob.

Eyes bare, facets of equal size throughout, closely contiguous for a considerable distance above; ocelli on a prominent raised portion; antennæ small, arista bare, hairlike; insertion of antennæ very distinctly below middle of profile; postocular orbits only visible towards lower extremity of head; profile as in Figure 2. Mesonotum finely punctured; scutellum without distinct rim. Abdomen not broader than thorax, narrowed at base, segments more distinct than in other genera, hypopygium small, usually protruded. Legs slender. Third vein ending as far before wing-apex as second branch of media does behind it, the branches of media often fused at apex of discal cell; apex of discal cell distinctly proximad of apex of stigma.

*Female.*—Agrees in color with the male.

Frons slightly less than one-third head-width, slightly narrowed anteriorly, incised central line weak; antennæ as in male but rather larger; profile as in Figure 1.

Length, 2–3 mm.

The original description gives the District of Columbia as the type locality. I have seen one male from the Museum of Comparative Zoology collection labeled "O. Sacken coll." which bears the locality label West Point. The species has been recorded from New Jersey and the White Mountains, N. H. I have seen a specimen from Opelousas, La., April, 1897, submitted by C. W. Johnson, and others from Lafayette, Ind., July 11 (J. M. Aldrich); and Urbana and Monticello, Ill., June 20 to July 4, 1914 (C. A. Hart and J. R. Malloch).

Only one male of the type series of *pulcher* in the Museum of Comparative Zoology, besides the type specimen, belonged to this species, the others being *Neopachygaster maculicornis* and *Eupachygaster* sp., probably *punctifer*.

Nothing is known of the early stages of our North American species. The European congener, *atra* Meigen, has been reared from decayed *Ulmus* wood. There are records of the species having also been reared from *Populus alba* and *Pinus sylvestris*, but there is considerable doubt as to the correctness of these, as pointed out by Verrall.†

*Berl. Ent. Zeitschr., 1863, p. 10.

†*British Flies*, Vol. V, Stratiomyidæ, p. 71.

The European species *leachii* Curtis, about the generic position of which there is a doubt, has been recorded by Perris at different times as bred from *Boletus* in a hollow oak, from rotten wood from oak and from turnip stems.*

**Eupachygaster** Kertesz.

I have provisionally placed the following species in *Eupachygaster*, a genus erected by Kieffer for the reception of *tarsalis* Zetterstedt.† It is unfortunate that I am not in possession of both sexes, for this fact prevents me from arriving at a definite opinion regarding the generic status of the species. From *tarsalis* the present species differs in having the antennæ inserted at middle of frons, but I consider this character insufficient alone to permit a generic separation. The specimen I refer to in the notes on the present species as being in the Museum of Comparative Zoology at Cambridge, Mass., has puzzled me. If it is a female it undoubtedly represents a distinct species; whereas if it is a male *punctifer* it is a departure from the rule in having the third antennal joint larger than in the female; and because of the wide frons the species would also be removed from *Eupachygaster*.

**Eupachygaster punctifer,** n. sp.

*Female.*—Glossy black. Frons glossy black, with a subopaque M-shaped mark on center, the surface of which is clothed with short silvery pile; lateral margins silvery from lower extremity of the M-shaped mark downward; face brownish, clothed with silvery pilosity; proboscis yellow; antennæ yellow, inner surface from before apex of third joint to apex of sixth distinctly brownish; arista white, yellowish at base. Thorax glossy black, disc with numerous small punctiform groups of silvery scalelike hairs, those on median and submedian lines forming three irregular narrow stripes; scutellum without silvery hairs. Abdomen glossy black, the punctiform groups of silvery hairs present except on disc of first and second segments. Legs pale yellow; fore coxæ black, mid and hind coxæ and all femora except their bases and apices brown. Wings clear; veins and stigma yellow. Halteres brown, knob white except the extreme base.

Frons, at vertex, about one-fourth the width of head, the sides diverging towards antennæ, at its lower extremity one-third the head-width; ocellar region distinctly raised, profile as in Figure 13; antennæ short, apical portion consisting of at least five joints; basal joint of arista short and broad, apical joint elongate, densely clothed with short hairs, so that it appears to be flattened and rather sword-shaped (Fig. 7).

*Ann. Soc. Ent. France, 1870, p. 212, l. c. 1876, p. 180 and p. 193.
†1er Cong. Intern. d'Entomol. Brux., 1910, p. 31. 1911.

Dorsum of mesonotum and scutellum distinctly punctured; between the groups of silvery hairs on mesonotum, and on the scutellum also, are numerous, less conspicuous, silvery hairs; shape of scutellum when viewed from the side as in Figure 8. Abdomen short and broad, disc of segments punctured as mesonotum. Legs rather stout, surfaces with very short hairs. Fork of third vein slightly sloping towards apex of wing, distance from apex of fork to apex of third less than one-third the distance from apex of stigma to apex of fork.

Length, 3.5 mm.

Type locality, Algonquin, Ill. (W. A. Nason).

A specimen, without locality data, from the Loew collection and placed with the type *Pachygaster pulcher*, has the antennæ considerably larger, the third joint very much deeper than long, the arista slender, with very short pubescence, the silvery pile arranged in irregular narrow stripes instead of punctiform groups; no noticeable silvery pile on abdomen. I am rather inclined to the opinion that this specimen is the female of a distinct species, but because of uncertainty as to the locality from which it was obtained and a disinclination to dissect a specimen which does not belong to me, I am forced to leave the matter in doubt, even as to sex.

Dr. Kertesz has described the genus *Vittiger** from Peru. This genus closely resembles *punctifer* in the arrangement of the thoracic pilosity, antennal structure, and venation. The principal differences between the two genera lie in the position of the antennæ, which in *Vittiger* are inserted below the middle of the head, in profile, while in *Eupachygaster* they are at the middle; in the form of the scutellum; and in the form of the fore legs, which in *Vittiger* are distinctly stronger than the other pairs and have the tarsi flattened, whereas in *Eupachygaster* the legs are all of equal strength.

The life history of the present species is unknown. *E. tarsalis* has been reared from larvæ found on *Pinus* in Scotland, and on *Populus* in England. Lundbeck has recorded the same species from apple and oak, while Verrall indicates that Dr. Sharp reared it from *Fagus*. The pupal case is figured by Verrall,† Figure 11 in present paper being a reproduction of that by Verrall.

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*Ann. Nat. Mus. Hung., Vol. 7, 1909, p. 395.

†*British Flies*, Vol. V, Stratiomyidæ, Fig. 100, p. 75.

**Neopachygaster** Austen.

As indicated in the introductory remarks to this paper, *Neopachygaster* was erected for the reception of a single species, *orbitalis* Wahlberg (as *meromelæna* Perris), a species which is very closely related to *maculicornis* Hine, considered congeneric with it by the present writer. It is not difficult to separate the genus from *Pachygaster* in the male sex, as the eyes in the latter are contiguous above, but the females are very much alike, both having the eyes separated, and more obscure characters must be used to separate this sex. Austen has used the form of the posterior orbits as the character for the separation of the females, stating that in *Pachygaster* these are produced in the form of a "prominent ridge," while in *Neopachygaster* they are not. It is apparent from the figures given by Verrall that what Austen referred to, unless he was using *minutissimus* for comparison, was the distinct production of the posterior orbits on their lower half, which is almost indistinguishable in *Neopachygaster*. A character which very probably holds good and is of considerable value also, though not mentioned by Austen, is the shape of the head, which in *Pachygaster atra* Meigen is elongate, the eye being longer than high, while in *Neopachygaster orbitalis* it is short, the eye being distinctly higher than long. Unfortunately, it is not possible to use this character here unless one is prepared to erect a new genus for *pulcher* Loew, as this species has the eyes of the male contiguous above and the head higher than long, i. e., intermediate between *Pachygaster* and *Neopachygaster*. For a discussion of this point see under *Pachygaster*. It is not clear whether in *orbitalis* the dark mark on the antennæ is of the same nature as in *maculicornis*—glossy and possibly of a sensory nature—though Austen's description leads me to infer that it is. If this supposition is correct the presence of this mark or organ on the antennæ might be used as a character for the separation of the genera in both sexes.

**Neopachygaster maculicornis** Hine.*

*Male.*—Glossy black. Head black, eyes in life with a purple tinge; antennæ yellow, a conspicuous glossy dark brown spot on inner surface of third (complex) joint; depressions above antennæ and the lateral

*Ohio Naturalist, Vol. 2, 1902, p. 228 (Pachygaster).

margins of face with distinct silvery pile; proboscis yellowish apically, brown basally. Mesonotum with silvery hairs which are very dense, backwardly directed, and decumbent; pleuræ with a vertical stripe of silvery hairs on center; scutellum with less conspicuous hairs than mesonotum. Abdomen with short whitish hairs, which are much more sparse than those on thorax. Legs yellow, coxæ, except at apices, and femora, except at bases and apices, blackish brown. Wings clear, veins yellowish. Halteres yellow, knobs white.

Frons about a fifth the width of the head, parallel-sided from posterior ocelli to a short distance above antennæ, where it widens gradually; ocelli situated on a slight prominence; antennæ small, third joint disclike, the glossy area on inner side very noticeable; arista slender, bare, apical; eyes bare. Thorax with distinct suture on each side at middle, the portions immediately posterior to suture distinctly swollen; process in front of wing-base distinct; scutellum directed slightly upward, blunt apically, and unarmed. Abdomen broader than long, segments poorly defined; hypopygium small, generally protruded. Legs slender, tarsi not thickened. Apex of discal cell slightly proximate of apex of stigma, distance from fork of third vein to apex of latter about equal to preceding section of costa.

*Female.*—Differs from the male in having the frons slightly wider, the antennæ appreciably larger, profile (as in Fig. 16), the thoracic dorsal pilosity shorter and brassy in color, except anteriorly on the sides, and in being slightly larger.

Length, male, 2–2.5 mm.; female, 2.5–3.5 mm.

Originally described by Hine from Onaga, Kansas, and doubtfully referred to *Pachygaster*. I have examined one of the paratypes. I have seen examples from Havana, Ill., taken on the Illinois River bottoms June 19, 1909; from Plainview, Ill., in apple orchard, May 3, 1915 (J. R. Malloch); from Lafayette, Ind., June 6 and July 24 and 26 (J. M. Aldrich); from Ithaca, N. Y., July 15, 1907 (A. D. MacGillivray); from Lincoln, Neb., marked "bred from *Pulvinaria innumerabilis;*" and five specimens from the series of *Pachygaster pulcher* in the Museum of Comparative Zoology at Cambridge, Mass., two females of which bear the label D. C., one labeled "Loew coll.," the other, "pulcher" and "O. Sacken," and two males and one female without locality labels, one bearing the number 77, and all three with the label "Loew coll."

As pointed out by Aldrich in his "Catalogue of North American Diptera" (p. 192), Loew had two species before him when he described *Pachygaster pulcher*—a fact which invalidates his description of the female. The description of the male was drawn from the specimen bearing the type label, and this

is accepted as Loew's species. (An examination of Loew's material disclosed the fact that he had 3 species—or at least there are now three—in his type series).

The record on the Nebraska specimen, given above, is undoubtedly an error, the larvæ having fed in the bark of the tree on which the *Pulvinaria* were, and not on the insects.

*Neopachygaster orbitalis* was reared from larvæ found in a decaying holly tree (*Ilex*) at Lyndhurst, New Forest, England, by Dr. D. Sharp on several occasions. Wahlberg's record "Hab. in ligno Populi caseo ad Gusum Ostrogothiæ" has been supposed to indicate that he reared the species from poplar, but nothing definite is known on the point. Verrall suggests that the species may be found upon holly exclusively.

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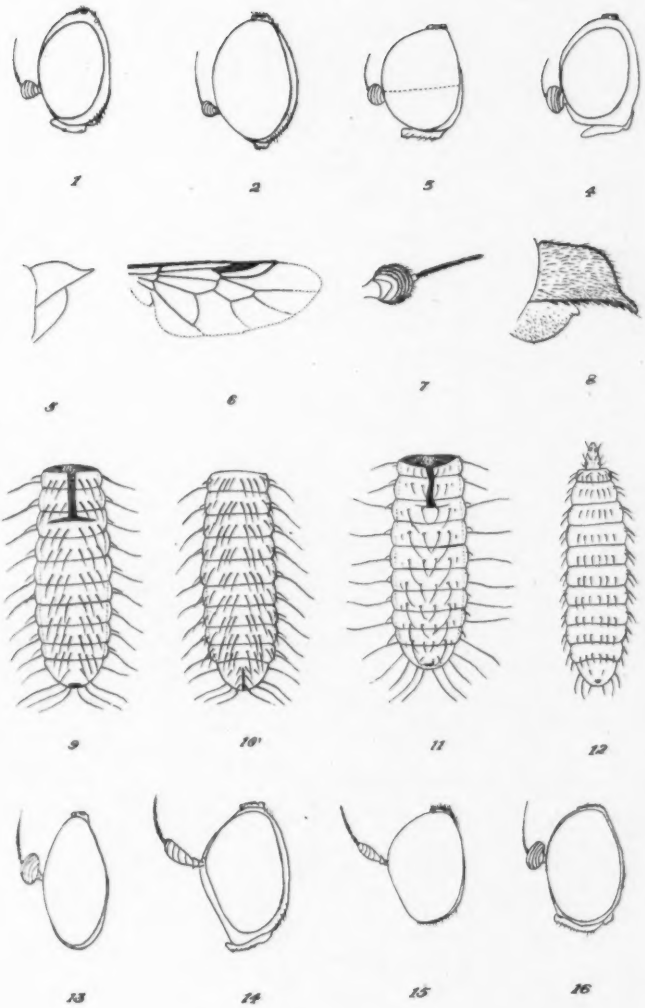
EXPLANATION OF PLATE XXV.

Fig. 1. *Pachygaster pulcher*, head in profile, female.
Fig. 2. *Pachygaster pulcher*, head in profile, male.
Fig. 3. *Zabrachia polita*, head in profile, male.
Fig. 4. *Zabrachia polita*, head in profile, female.
Fig. 5. *Johnsonomyia aldrichi*, scutellum in profile, male.
Fig. 6. *Zabrachia polita*, wing.
Fig. 7. *Eupachygaster punctifer*, antenna of female.
Fig. 8. *Eupahygaster punctifer*, scutellum in profile, female.
Fig. 9. *Zabrachia polita*, pupal exuvia, dorsal view.
Fig. 10. *Zabrachia polita* pupal exuvia, ventral view.
Fig. 11. *Eupachygaster tarsalis*, pupal exuvia, dorsal view.
Fig. 12. *Neopahcygaster orbitalis*, pupa, dorsal view.
Fig. 13. *Eupachygaster punctifer*, head in profile, female.
Fig. 14. *Johnsonomyia aldrichi*, head in profile, female.
Fig. 15. *Johnsonomyia aldrichi*, head in profile, male.
Fig. 16. *Neopachygaster maculicornis*, head in profiel, female.

Figs. 11 and 12 are copied from Verrall's British Flies, the others are original.




*J. R. Malloch.*

# ON THE PRESENCE AND ABSENCE OF COCOONS AMONG ANTS, THE NEST-SPINNING HABITS OF THE LARVÆ AND THE SIGNIFICANCE OF THE BLACK COCOONS AMONG CERTAIN AUSTRALIAN SPECIES.*

By William Morton Wheeler.

It has long been known that in three of the five subfamilies of ants, the Dorylinæ, Myrmicinæ and Dolichoderinæ, the larvæ spin no cocoons before pupation, and therefore remain nude, or uncovered in this instar. There is apparently no exception to this rule in these three subfamilies. The cocoon is present, so far as known, in all members of the subfamily Ponerinæ, with the single exception of a small African ant, *Discothyrea oculata*, and is lacking among the Camponotinæ only in a few whole genera and a few sporadic species of other genera. The pupæ of the genera *Prenolepis* and *Œcophylla* are naked, and in some species of *Formica* (e. g. the circumpolar *F. fusca* L. and its vars. *subsericea* Say, *neorufibarbis* Emery, etc. in North America) one often finds only naked or both naked and cocooned pupæ in the same nest. This is also the case, though much more rarely, in certain species of *Lasius*. A few species of the large paleotropical genus *Polyrhachis* also lack the cocoon in the pupal stage, as I shall show in the sequel.

These facts naturally suggest the inference that the cocoon, inherited from the ancient wasp-like ancestors of the ants, has been retained in the most primitive subfamily, the Ponerinæ, from which, by common agreement, the four other subfamilies are descended, and that it has been lost in three and is tending to disappear in the fourth of these. Certain authors, indeed, seem to believe that the disappearance has been comparatively recent in the phylogenetic history of the Formicidæ. In this sense I interpret the following remarks of Janet (1896): "We are no doubt witnessing in the ants the disappearance of this protective envelope, which is rendered unnecessary by the incessant care devoted to the progeny. From the point of view of the evolution of instinct, it is interesting to note that

*Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 95.

the disappearance is not accomplished gradually, by successive attenuation or evanescence of the cocoon, but suddenly, so to speak, since larvæ that are similar and give rise to similar adults, make an absolutely perfect cocoon, which shows no signs of reduction, or make none at all. This may be cited as an example of the sudden changes that may supervene in the habits of an animal. It illustrates the conclusions embodied in a communication made by my brother, M. Armand Janet, to the Leyden Congress. These conclusions, deduced from considerations of rational mechanics applied to the problem of the species regarded as a position of equilibrium, tend to show that the differences obtaining between a form and its derivatives are more probably produced by rather sudden saltations than by insensible and continuous variations."

In other words, Janet regards the disappearance of the cocoon in ants as due to what we now call "mutation," and intimates that in certain species the process is still going on. I am willing to grant the partial truth of this contention, but I have recently found evidence to prove that, far from being a recent loss, the disappearance of the cocoon, in certain genera of ants at least, had already taken place not less than two million years ago. Among the Dolichoderinæ of the Baltic amber, which is of Lower Oligocene Tertiary age, I find the pupæ of certain species already lacking the cocoon, and this structure is likewise absent in a species belonging to the Camponotine genus *Prenolepis* (*P. henschei* Mayr) in the same formation (1914). Facts like these are calculated to impress us with the immense antiquity of many apparantly trivial structures and to convince us that we cannot dispense, even in these days of experimental biology, with a certain amount of "phylogenetic speculation."

What has led to the disappearance of the cocoon in the Myrmicinæ, Dorylinæ and Dolichoderinæ and in a few genera and sporadic species of other genera among the Camponotinæ? This question no doubt admits of several answers. Janet, as we have seen, believes that the cocoon became superfluous and disappeared because it was replaced by the fostering care and protection of the workers of the colony. But if this is the case, why do the most formidable of all ants, the Australian "bull-dogs" (*Myrmecia*), retain the cocoon and such feeble

species as many Dolichoderinæ (*Leptomyrmex*, *Tapinoma*, *Bothriomyrmex*, etc.) dispense with it? And why is it retained by the fierce *Formica sanguinea* and so often absent in *F. fusca* and its varieties, the gentle slaves of this ant? That the presence of the cocoon is primitive and its suppression a secondary phenomenon must be granted, and it is evident that the loss of the structure must be due primarily either to a loss of the spinning instincts on the part of the larvæ or to a change in the instinct of the adult worker ants in so far as these instincts are concerned with the treatment of the larvæ. The latter change might conceivably consist in a lapse of the habit of burying the mature larvæ in the earth or in covering them with particles of earth or refuse, since ant larvæ are known to be quite unable to spin their elliptical cocoons unless thus temporarily enveloped with foreign particles to which they can attach the thread from their sericteries.

The frequent appearance of nude pupæ in the typical *Formica fusca* and some of its varieties may be attributed to the fact that these forms are peculiar to high altitudes and latitudes, where the reproductive season of the colony is considerably abbreviated. The omission of the cocoon would seem, therefore, to be due to "tachygenesis," or acceleration of ontogenetic development, since the spinning of this envelope not only requires a number of hours and an expenditure of energy and material, and therefore delays pupation, but the envelope itself is probably in some degree a nonconductor and would therefore tend to prolong development under circumstances that demand a very rapid utilization of the sun's heat by the pupa if it is to reach maturity at the proper time. The loss of the pupal covering in the Myrmicinæ, Dolichoderinæ and Dorylinæ in the remote past may have been due to the same or similar causes.

That the behavior of the workers of the ant-colony in some species does actually influence the spinning activities of the larvæ is indicated by the following facts. In the great majority of larvæ which use their spinning glands, these organs are called into activity only at the end of the larval stage and for the purpose of making the cocoon, but within recent years several observers have called attention to a series of tropical ants belonging to at least three very different genera of Camponotinæ,

namely, *Œcophylla*, *Camponotus* and *Polyrhachis*, which have the extraordinary habit of using their larvæ for the purpose of spinning silken nests for the colony. This habit has been observed by Ridley (1890, 1894), Hammond (Green 1900), Green (1900, 1903), Doflein (1905, 1906) and Bugnion (1909) in the red tree-ant of India (*Œcophylla smaragdina*), by Saville-Kent (1891, 1897), Dodd (1902), O'Brien (1910) and myself in the green tree-ant of Northeastern Australia (*Œ. smaragdina* var. *virescens*), and by Chun (1903) in *Œ. longinodis* of the Kamerun. More recently Goeldi (Forel 1905) has observed this habit in a South American *Camponotus* (*C.* [*Myrmobrachys*] *senex* F. Smith) and Jacobson (Forel 1911, Wasmann 1905) and Karawaiew (1906) have observed the same behavior in several species of *Polyrhachis*. Green (1903) found that although the larval *Œ. smaragdina* is employed as a shuttle in spinning the silken portions of the nest, it does not spin a cocoon for itself, but forms a naked pupa. He says: "This seems to be explicable only on the theory that the silk that would normally be employed in the construction of the cocoon is systematically converted to the purpose of nest building, and that the larvæ have consequently lost the habit of cocoon formation." This was a natural view to take, especially as Green (1900) believed that only full grown larvæ were used in spinning the nest. The conditions, however, are more complicated than they appeared to Green, since later observers have shown that *Œcophylla* uses only its very young larvæ in nidification, and that cocoons are actually formed by the larvæ of many of the nest-spinning species of *Polyrhachis*. As I have lately had an opportunity to study the nest-spinning habits of *Œ. virescens* in Australia and am able to record a few new facts concerning an Australian *Polyrhachis* and a Central American *Camponotus* not hitherto known to produce silken nests, I take this occasion to transcribe a few observations from my note-books.

I find the earliest mention of the green tree ant in Capt. Cook's narrative of his first voyage. He landed May 23, 1770, somewhere in the neighborhood of the present Townsville, on the coast of Northern Queensland, "within the point of a bay, which led into a large lagoon, by the sides of which grows the true mangrove. There," he says, "were many nests of a singular kind of ant, as green as grass, in the branches of these

mangroves," etc. This passage came to my mind when I landed for an hour at Lucinda Point, north of Townsville, and found the nests of the green ants on the mangroves just as they had been observed by Capt. Cook. Later, while sojourning for a few weeks at Cairns on the Cape York Peninsula, I had an opportunity to become well acquainted with this ant. In the outskirts of this pretty town it may be found on all kinds of trees and bushes, building its nests in the leaves from a few feet above the ground to the inaccessible branches of the highest *Melaleuca* trees. The thorax and legs of the slender workers of *Œ. virescens* are brownish straw yellow, the gaster bright green and the head tinged with the same color. Usually it prefers trees with rather thin, flexible, lanceolate leaves a few inches in length, which may be easily drawn together, but occasionally it makes its nests even on wattles with thick phyllodes. The nests are more or less elliptical and vary in size from a few inches to a foot or more in length and to eight inches in diameter. Smaller nests or tents, for the accomodation of Homoptera, may consist of only a few leaves, but larger ones often take up nearly all the leaves on a small branch or on two neighboring branches. Some of the nests are very beautifully constructed, the leaves being drawn together and plaited in such a manner that the superficial layer forms a smooth, mosaic covering. The interior of the nest consists of the enclosed, more or less crowded or curled leaves.

On several successive days I endeavored to observe the spinning habits of *virescens* by tearing small rents in the nests and waiting to see the ants repair them. Occasionally I saw some of the workers line up on the outside of the nest as described by previous observers, and draw the leaves on each side of the rent together, but I failed to see the spinning of the silken film across the gap. On October 16th, however, I came upon a remarkable nest in process of construction. It was 3 o'clock in the afternoon and the nest hung in the shade about 8 feet from the ground on a wattle branch, which I partially broke in order to bring the structure to a level with my eyes, where I could watch it without disturbing the ants. It was very large and somewhat flattened, about 14 inches long, 7 inches broad and 4 inches thick. The leaves (or rather phyllodes) had evidently just been brought together, as the

whole outer surface was covered with hundreds of ants, all forming living sutures along the contiguous edges of the leaves. In most cases these sutures consisted of a single row of ants, side by side, with their mandibles grasping the edge of one leaf and the large claws of all their backwardly directed feet fixed into the edge of another adjacent leaf. Where the gap between the leaves of the outer layer was too wide to be spanned by single ants, there were parallel chains each consisting of two to seven ants, each ant holding the petiole of the ant in front in its mandibles and being grasped in the same place by the ant behind, exactly as described by Dodd for *Œ. virescens* and figured by Bugnion for the true *smaragdina* of Ceylon.*

The longer chains often ran diagonally across the shorter. The nest presented a startling appearance, with these hundreds of green ants immovably fixed on its outer surface and accentuating the more or less contiguous borders of the leaves. Then I noticed that there was great activity on the branch leading to the nest. Files of workers were running along it to and from the nest and could be traced to two much smaller nests consisting of dead leaves on an adjacent tree about 30 feet away. The colony had evidently outgrown these nests and was in the act of building the more commodious domicile I had been observing. Closer inspection showed that about one in a dozen of the workers coming to the new nest was carrying in its mandibles a minute milk-white larva, and as the larvæ accumulated, I was able to observe all the stages in the spinning of the silken film. Many of the ants worked from the inside, but quite a number stationed themselves on the outside of the nest where I could see them very clearly under my pocket lens, while they moved their larvæ back and forth as living shuttles from the edge of one leaf to that of another, pausing only while the larvæ attached their extremely delicate threads to the surface of the leaf. A single ant would sometimes work in the same spot for 10 to 20 minutes, moving its larva so nearly through the same arc as to produce a stout silken band or cord from the

*The question naturally suggests itself as to whether the greatly elongated petiole of *Œcophylla* is not an adaptation to this peculiar use. I have recently (1914) called attention to the fact that the fossil species of *Œcophylla* (*brevinodis* Wheeler and *brischkei* Mayr of the Baltic amber and *sicula* Emery of the Sicilian amber) have a shorter petiole than the recent *smaragdina*. This indicates, perhaps, that the species of the Lower Oligocene and Miocene had not yet acquired or were merely in process of acquiring the habit of forming chain sutures.

individually invisible threads. In other cases the movements were more varied so that the threads crossed and recrossed one another till they gradually formed a delicate film or tissue. Only very young larvæ, about 2-3 mm. in length, were employed. The nest was watched till darkness came on. There was no movement on the part of the ants that were warping and holding the stiff leaves in place, and the weaving workers were still toiling when I was compelled to return to my hotel for the night.

At nine o'clock on the following morning, when I hastened to the nest, I found few ants on its outer surface and none holding the leaves in position, for during the night the ants had filled out all the narrow spaces with white silken tissue. This must have represented an enormous amount of labor on the part of the workers and a corresponding expenditure of material on the part of the larvæ. On gently opening a few of the sutures so that I could look into the nest, I found that the chains of workers were now stationed on the inside warping the leaves while the larvæ were being employed in spinning them together to form chambers. The spaces between the leaves were full of ants and brood as the whole colony had now moved into the new quarters. The day was growing warm and the leaves of the nest were beginning to wilt as the result of my breaking the branch on the previous day.

At three o'clock I again visited the nest and was startled by the great change which it had undergone. The heat of the sun had dried the thick phyllodes of the wattle branch till they had curled and ruptured the silken tissues, so that the whole nest was disintegrated, so to speak, and had been entirely deserted by the ants. Under natural conditions the leaves of the nests also die and dry up after the ants have been living in them for some time, but so gradually as not to break the silken sutures.

When one realizes the great expenditure of labor and valuable material in constructing one of these nests, one is not surprised to find that the ants are exceedingly aggressive in defending their property. When a nest is broken open or even roughly shaken the ants rush out and gather in great numbers at one or a few points on its outer surface where they assume a peculiar threatening attitude. Doflein has given a figure of this attitude in *Œ. smaragdina*, but his figure is not altogether

accurate, at least for the var. *virescens*. This ant rises on its middle and hind legs, so that they are nearly straight, the fore pair are thrust out into the air and often waved about as if to grasp the intruder and the mandibles are opened as widely as possible. A slight shock to the nest when the workers are thus congregated will precipitate the whole mass of them over one's clothes and head. Then one may notice a peculiar method of behavior which is evidently merely a modification of the posture assumed by the ants when they are holding the leaves together during the construction of the nest. After digging the claws of their backwardly directed legs into one's skin, they seize the skin in front of them with their mandibles and begin to pull slowly and steadily. This produces a peculiar sensation as if the skin were tightly bound with cords. It is especially marked when a row of ants seizes the skin of one's neck with the mandibles and fastens the claws into the edge of one's collar.

I was unable to study the founding of the colonies of *virescens* as the ants had not yet produced their annual generation of sexual individuals at the time of my visit to Queensland, but Mr. F. P. Dodd informs me that the huge, recently fecundated queen, after cutting off her wings, takes up her abode in a curled leaf. In the course of a few days she lays a batch of eggs and when they hatch she employs the young larvæ in spinning enough silk to bind the edges of the leaf together. A figure (Fig. 135) and a few brief notes published by Maxwell-Lefroy and Howlett in their work on Indian insect-life (1909) suggest that the queen of the typical *smaragdina* founds her colony in the same manner.

The large genus *Polyrhachis* has been recently divided into several subgenera. I have found that the numerous Australian species of three of these, *Campomyrma*, *Hagiomyrma* and *Chariomyrma*, all nest in the ground under stones or pieces of wood, except *Hagiomyrma semiaurata*, which nests in great logs. The small, shining black species, with peculiarly arched thorax, now referred to the subgenus *Cyrtomyrma*, however, inhabit silken nests attached to the leaves of trees. This is true, at least, of the Australian *C. lævior* Roger and its var. *yorkana* Forel, which are merely forms of the Indomalayan *rastellata* Latreille. I found the nests of *lævior* to be of small size and usually built on thick, broadly lanceolate leaves such as those

of the mangrove and a species of *Wurmia*. Sometimes two leaves have their edges spun together with a silken tissue, or a silken bladder with a short tubular entrance is constructed on the lower surface of a single leaf. The outer surface of the silk is thickly covered with minute vegetable particles. There are only 25 to 50 ants in a colony and the pupæ are always naked. This is interesting, because all the other nest-spinning species of *Polyrhachis*, of which at least 20 are mentioned in the literature, are described as having the pupæ enclosed in cocoons just as they are in the species that nest in the ground or in logs. It is evident, therefore, that the larvæ of the subgenus *Cyrtomyrma*, like those of *Œcophylla*, though actively sericiparous in the construction of the nest, no longer spin a pupal envelope.

All the species of *Œcophylla* and *Polyrhachis* are confined to the Old World tropics. The third genus, *Camponotus*, is cosmopolitan and comprises several hundred species, nearly all of which nest in the ground or in dead wood. Only a small number of species and these, so far as known, peculiar to tropical America, build silken nests. Several years ago Goeldi (Forel 1905) observed that the Brazilian *C. senex* employs its larvæ in the construction of a somewhat globular silken nest on trees, and the var. *textor* Forel of the same ant is known to make a similar nest in Central America. I am able to add a second species, a beautiful little, opaque, red ant, *C. (Myrmobrachys) formiciformis* Forel, to the list of forms with the same habit. Dec. 28 and 30, 1911, my wife discovered two nests of this ant while we were walking in the neighborhood of Escuintla, Guatemala. One was between two broad liana leaves, which had been converted into an elliptical nest about four inches long and three inches broad by having their edges bound together with a broad film of white silk (Fig. 1). In this nest the silk was quite clean, like that of *Œcophylla*, *i. e.*, without admixture of any foreign material. The other nest, of about the same size, was of a different appearance. It consisted of silk spun around the radiating petioles of a cluster of pinnate leaves on the branch of a leguminous tree. No leaves were included in the walls of the nest so that very large quantities of silk had to be produced, and this silk was of a gray color and covered with numerous particles of extraneous vegetable matter. Each of the nests contained a flourishing colony of several hundred very active ants, which

left the nest with their larvæ and pupæ when it was violently shaken. Although I did not see the larvæ in the act of being used as shuttles in the construction of the nest, there can be no doubt that they are thus employed. The pupæ were all enclosed in white cocoons like those of other small species of *Camponotus*.

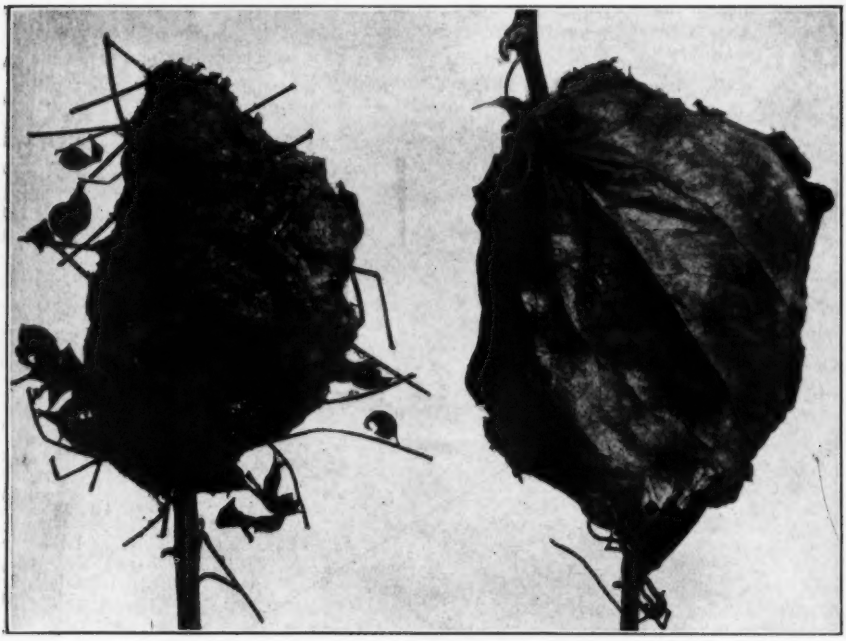


FIGURE 1

Fig. 1. Silken nests of *Camponotus* (*Myrmobrachys*) *formiciformis* from Guatemala, about one-half natural size.

The workers, however, unlike those of nearly all the species of the genus, were monomorphic as in the various species of *Œcophylla* and *Polyrhachis*. In *C. senex* the workers are also practically monomorphic, so that it would seem that the habit of employing the larvæ for spinning the nest tends to make them develop into adults of uniform stature and shape. It is not easy to understand why this should follow.

Still another inference may be drawn from the presence or absence of cocoons among the various nest-spinning ants. As we have seen, the cocoons are always present, so far as known, in *Camponotus*, even in the nest-spinning species; in *Polyrhachis* the cocoon is rarely absent and then only in the species of the subgenus *Cyrtomyrma*, whereas in *Œcophylla* it is always absent. Very few species of *Camponotus* spin nests; a number of species of *Polyrhachis* have acquired this habit, and all the species of *Œcophylla* exhibit it in its highest manifestation. This is shown also by the hypertrophic development of the sericteries of young *Œcophylla* larvæ, as observed Chun (1903) and Karawaiew (1906). Apparently, therefore, in this genus the spinning habit has been shifted back *en bloc* to an early larval stage and is no longer manifested for cocooning in late larval life; whereas in *Camponotus* and *Polyrhachis* (excepting the species of *Cyrtomyrma*) more mature larvæ are used as shuttles and the cocoon-spinning instincts have not been suppressed.* The employment of the larvæ as instruments for spinning a silken nest in at least three very different genera is only one of several cases of convergent development among ants. While studying the Australian species during the autumn and winter of 1914, I detected another case of an equally adaptive convergence in the coloration of the cocoon. In the great majority of ants the cocoons are white, cream, or pale buff-colored. In some Ponerinæ (*Odontomachus*, *Stigmatomma*, etc.) they are brown, but the cocoons of the species to which I refer are dark brown or black. Such cocoons I have found in three very different genera of Ponerinæ, namely, *Diacamma*, *Rhytidoponera sens. str.* and *Leptogenys* (subgenera *Lobopelta* and *Odontopelta*), and as nothing has been published on the habits of the species in question, I here subjoin a few of my field notes.

*Wasmann (1905), in his rendering of Jacobson's observations on *Polyrhachis* (*Myrma*) *dives* F. Sm., states that one of the larvæ used as a shuttle measured 5 mm. It must, therefore, have been much more nearly full-grown than the larvæ employed by *Œcophylla* for the same purpose. In this connection reference may be made to *Technomyrmex bicolor* Emery subsp. *textor* Forel of Java, which, according to Jacobson (Forel, 1909) inhabits, on the bark of trees, little nests 2 cm. long by 1 cm. in diameter, consisting of silk mixed with vegetable detritus. These nests are described as resembling those of *Polyrhachis psena* in miniature. If, as Forel remarks, these nests are really the work of the *Technomyrmex*, we shall have to regard this as a fourth genus which has independently acquired the habit of employing its larvæ in nidification. This would be of considerable interest, because *Technomyrmex* is a Dolichoderine ant, whereas all the nest-spinning species above mentioned are Componotinæ.

The only species of *Diacamma* known to occur in Australia is the bronzy black and beautifully sculptured *D. australe* (Fig. 2). The remainder and great majority of the species of the genus are Indomalayan. I found *australe* rather common in several localities in Queensland (Cairns, Kuranda, Koah, Townsville) nesting in the ground in open, sunny and more or less grassy places. The nests are craters four inches to a foot in diameter and two to six inches high, with a very large central opening, often 1 to 1½ inches in diameter. This opening leads almost directly into a few large chambers situated

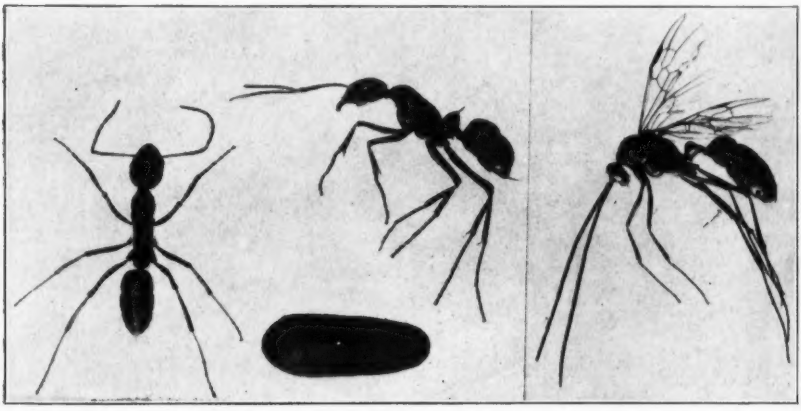


FIGURE 2 FIGURE 3

Fig. 2. *Diacamma australe*. Workers and cocoon x1⅔.
Fig. 3. *Diacamma australe*. Male x1⅔.

in the crater, and from them galleries descend into the ground, apparently to some depth. The outer surface of the crater is often covered with growing grass or other plants. The colony of ants numbers about 50-100 individuals. They are rather timid and usually retreat into the nest at the slightest alarm. Their movements are exquisitely soft and graceful. Their sting is rather feeble, except when it comes in contact with the thin skin on one's wrists or between the fingers. In the "Genera Insectorum" Emery enumerates 13 species of *Diacamma* and one of these, the Indian *D. rugosum*, is so well known that 22 varieties and subspecies of it have been described;

yet no one has ever seen a female *Diacamma*. In excavating the nests of *australe*, therefore, I scrutinized the ants very closely in the hope of finding the unknown female, but in vain. Though I searched dozens of nests, I saw nothing resembling a winged or deälated queen or even a worker with conspicuously enlarged gaster. I found plenty of larvæ and pupæ and in some of the nests during late October a number of males. These are bright, reddish yellow, with conspicuously long antennæ, and quite unlike the bronzy black workers. (Fig. 3). As I failed to find any differentiated queen and as all the pupæ were of the same size, I feel confident that in *Diacamma* the egg-laying function must be usurped by one or more fertile workers during the breeding season.

What impressed me most, while I was excavating the nests of *australe*, was the very dark brown or black color and tough consistency of the cocoons. I then remembered that I had received very similar cocoons with specimens of *D. scalpatrum* from India and of *D. cyaniventre* from the Philippines. Further study of the nests of *australe* soon gave a clue to the meaning of this unusually deep pigmentation of the pupal envelope. On the outer surface of two of the craters, which happened to be in shade at the time, I found heaps of cocoons fully exposed to the light. At first I supposed that they were the cocoons of dead or hatched pupæ, but on approaching the nests the wary workers at once carried them into the nest. Then on examining nests exposed to the bright sunlight, I found the cocoons in the superficial chambers so near the large entrance that they could be distinctly seen through it from the outside. Thus while the ants are careful not to place their cocoons in the direct rays of the sun they nevertheless expose them to diffuse daylight. The deeply pigmented cocoon evidently enables the pupa to utilize the heat rays while effectively protecting it from the light and ultra-violet rays. That ants are particularly sensitive to these latter rays has been proved by the experiments of Lubbock (1882), Forel (1886), Forel and Dufour (1902) and Miss Fielde (1904).

It occurred to me that the *australe* larvæ might spin a white cocoon like other ants and subsequently smear or saturate it with the black meconium, or intestinal contents, which all ant larvæ void just before pupating. But an examination of the cocoons showed this supposition to be erroneous, for the silken

threads of the cocoon are themselves dark brown and the meconium is deposited in a compact meniscoidal mass within the anal end of the cocoon as in other Ponerinæ and in the Camponotinæ. This differs from the conditions in certain moths (*Attacus atlas, Calosamia cynthia, Platysamia cecropia, Saturnia pyri, Eriogaster lanestris*) which, according to Batensen, Schawraw, Peterson, Dewitz, Verson and others, are able to adapt the color of their cocoons to that of the objects to which they are attached. In these cases the silk is white or colorless, but is stained by a dark excretory pigment mechanically

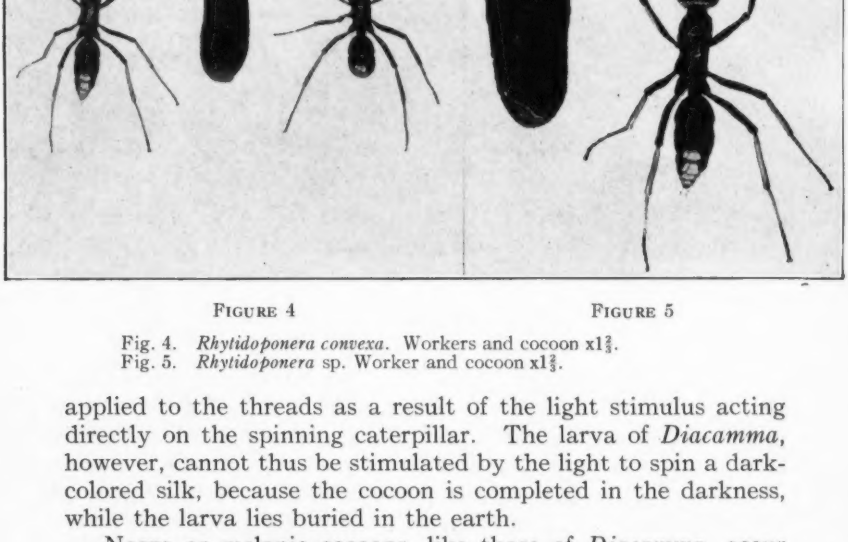


FIGURE 4 FIGURE 5

Fig. 4. *Rhytidoponera convexa*. Workers and cocoon x1⅔.
Fig. 5. *Rhytidoponera* sp. Worker and cocoon x1⅔.

applied to the threads as a result of the light stimulus acting directly on the spinning caterpillar. The larva of *Diacamma*, however, cannot thus be stimulated by the light to spin a dark-colored silk, because the cocoon is completed in the darkness, while the larva lies buried in the earth.

Negro or melanic cocoons, like those of *Diacamma*, occur also in many if not all species of *Rhytidoponera sens. str.*, (Figs. 4 and 5), a genus largely confined to Australia and New Guinea. The nests of *Rh. cristata* Mayr, *scabra* Mayr and *convexa* Mayr, with the var. *rufiventris* Forel, are very similar to those of *Diacamma australe*. They are craters with very large openings, built

in dry, open, sunny places and containing roomy chambers in which the black cocoons are often visible from outside the nest. I saw many nests of these ants in Queensland, especially in the environs of Brisbane, Townsville and Kuranda. In Kuranda I also found several species of *Leptogenys* of the subgenera *Lobopelta* and *Odontopelta* (*conigera* Mayr, *ebenina* Forel, *diminuta* Forel and its var. *yarrabahna* Forel and *turneri* Forel), which had very dark brown cocoons. These ants nest under stones and logs, but they seem to be very restless and one occasionally comes upon colonies moving to new nesting sites. At such times they carry their cocoons concealed underneath their bodies and between their legs and not held out in front as in other ants. It would seem that this concealment of the cocoons under the body is another devise for protecting them from the too direct rays of the sun. In this connection I may say that our single North American species of *Lobopelta* (*L. elongata* Buckley of the Gulf States) has brown cocoons, darker than those of our other ants, but paler than those of the Australian species. Other Australian Lobopeltas, such as *L. mutans*, which has small eyes and lives in rotten logs in the dark jungle, have pale brown cocoons. It is also worthy of note that winged females do not exist in *Rhytidoponera sens. str.* and *Leptogenys*. In the latter genus the female is wingless and almost exactly like the worker, and the egg-laying function in *Rhytidoponera* is very probably usurped by fertile workers as in *Diacamma*. Whether or not this correlation between the presence of black cocoons and the absence of differentiated females is more than a mere coincidence can be decided only by further investigations.

The fact I wish to emphasize is that the larvæ of *Diacamma*, *Rhytidoponera* and *Leptogenys*, while temporarily buried in the soil by their worker nurses, are able to spin cocoons preadapted in color to furthering their own development as pupæ by utilizing the heat of the sun and simultaneously excluding the deleterious light and ultra-violet rays. This utilization, moreover, is possible only through the co-operative agency of other individuals, *i. e.*, the worker nurses of the colony. The natural selectionist will probably insist that the origin of this melanism in an inert and extraneous pupal envelope can be explained only on the assumption of a survival of chance variations in the color of the silk spun by the larvæ. The possible contention of

the mutationist that a sudden and pronounced deepening of color of the cocoon would be necessary to insure the survival of the pupa will have little force, because even slight differences in color in the direction of greater opacity would be conceivably useful. But no variations would be significant unless the workers developed concomitantly the instinct to expose the cocoons to the heat and light on the surface of the nest. The neovitalist might claim, therefore, that the whole phenomenon is merely another instance of the prospective potency of the colonial psychoid. The modest naturalist who does not habitually abide in this tenuous atmosphere of supreme speculation will be satisfied to regard the melanism of the cocoons as a detail of the larger subject of the coloration of ants in general. As almost nothing has been published on this subject I may be permitted to consider it briefly in these concluding paragraphs.

Adult ants range in color from pale yellow (the primitive color of chitin) through various tones of red and brown to black and, through interference colors superadded to pigmentation, from bronze or æneous, through metallic green, blue and violet to metallic crimson. As here enumerated the shades evidently represent the order of the phylogenetic development of insect coloration generally, as indicated both by the ontogenetic sequence and the comparative study of the various species and genera. It is not so generally known that both the pigment and interference colors may be shown to depend intimately on the amount of light to which the ants are subjected and therefore on their mode of life.

The primitive, ancestral colors of the Formicidæ were probably red, brown or black, precisely those still prevalent in the majority of species inhabiting temperate regions or the forested portions of the tropics, where the workers, while foraging on the surface of the earth or of the vegetation, are exposed to a moderate insolation. From this condition we can trace three divergent lines of development, each terminating in a peculiar type of coloration, as follows:

1. A number of species have greatly exaggerated the negative phototropism, which is characteristic of most ants, and have therefore taken to a nocturnal or hypogæic mode of life. In all of these forms pigment has been lost, and the workers of the hypogæic species, which never come to the surface of the ground,

have become pale yellow or pale red or brown. Their eyes have diminished greatly in size or have disappeared. The males and females of these hypogæic forms, however, retain their deep pigmentation and large eyes because they retain the instinct to mate in the sunlight. The principal groups of hypogæic ants which exhibit this retrogressive color-development, at least in the workers, are: *Solenopsis*, (most species), *Machomyrma*, *Oligomyrmex*, *Carebara*, *Tranopelta*, *Aëromyrma*, some species of *Pheidole* and *Crematogaster*, the whole tribe *Dacetonii*, *Brachymyrmex* and the yellow species of *Lasius*, *i. e.*, those of the circumpolar subgenus *Chthonolasius* and of the North American subgenus *Acanthomyops*, many small Ponerinæ, *Ænictus*, *Dorylus*, some species of *Eciton*, *Leptanilla*, etc.

2. A number of species exhibit a progressive development from red, brown or black to the interference colors. This tendency to what may be called "metallescence" is observable in ants living in very hot, dry, sunny places, and is most pronounced in Australia, where it occurs in the following genera: *Chalcoponera* (nearly all species), *Rhytidoponera* (*convexa* var. *violacea* Forel), *Myrmecia* (*tarsata* F. Sm.), *Diacamma*, *Lobopelta* (some varieties of *conigera* Mayr), *Iridomyrmex* (many species, notably *detectus* F. Sm., *discors* Forel, *bicknelli* Forel, *cyanea* Wheeler, etc.), *Leptomyrmex*, *Camponotus* (some species of the subgenus *Myrmocamelus*), *Calomyrmex* (*splendidus* Mayr, *purpureus* Mayr and an undescribed species from the Cape York Peninsula), *Melophorus* (*æneovirens* Lowne and others), and *Polyrhachis* (*hookeri* Lowne, *schencki* Forel and *turneri* Forel). Some of the most conspicuous and widely distributed Australian ants, such as *Iridomyrmex detectus*, which is beautifully metallic purple, and other smaller species of the same genus, may be seen running about in the sunlight at a temperature of 115° to 120° F, when other ants are hiding in the soil, and in the deserts of Central Australia, where the temperature may rise even higher and the aridity is excessive, the tendency to metallescence is still greater. It is in this region that *Calomyrmex splendidus* and *purpureus* and their varieties occur and that *I. detectus* takes on the pronounced metallic green color of the var. *viridiæneus* Viehmeyer. The prevalence of interference colors in Australian ants is in marked contrast with their rare and sporadic occurrence in other regions. They occur in

none of the ants of the temperate zones, with the exception of a species of *Forelius* (*chalybæus* Forel) in Argentina and a species of *Pheidole* (*Ph. metallescens* Emery) in the Gulf States. Nor does metallescence occur in the ants of the tropics outside of Australia, if we except a few species of *Diacamma*, *Leptogenys* and *Polyrhachis* in the Indomalayan region, a few species of *Monomorium* and *Formica* in Mexico and several species of the genus *Macromischa* which has its center of distribution in the Antilles.

3. A third progressive line of development has led to certain large-eyed tropical ants, in which there is a contrast of black, yellow or red in bands, spots or larger areas involving certain segments or regions of the body. This diversification of color is often secured or enhanced by the development of areas of dense white or golden pubescence or pile, especially on the gaster. The tints are more vivid than in the ants of the first and most primitive category, and seem to indicate that their large-eyed possessors have some slight appreciation of color for its own sake, like the butterflies and many flower-frequenting flies and beetles. These ants live in open forests and are often very quick in their movements. They comprise such genera as *Pseudomyrma* in the New World tropics, *Opisthopsis* and *Podomyrma* in Australia and New Guinea and the "bull-dog" ants (*Myrmecia*) of Australia, Tasmania and New Caledonia. We may also include in this category many tropical species of *Camponotus*, *Polyrhachis* and *Dolichoderus*.

Not only is the coloration of ants thus influenced or determined by light, heat and aridity, but a peculiar adaptation in the investment, or pilosity and pubescence is observed in many species which are subjected to the extremes of these conditions in desert regions. Thus the species of *Deromyrma* (*cockerelli* André and *albosetosus* Mayr), of *Pogonomyrmex*, *Messor* and *Myrmecocystus*, the dominant forms in the deserts of our Southwestern States, are covered with silvery white hairs or pubescence or with both, and in the Sahara similar conditions prevail in *Cataglyphis* (formerly *Myrmecocystus*) and *Messor*. *Cataglyphis bombycina*, the most extreme of these forms in the development of pubescence, when running over the desert sands in the bright sun-light is said to resemble a drop of quicksilver. Obviously the brilliant white hairs serve to

reflect the light and heat and thus protect the ants' body from the effects of excessive insolation. Even within the confines of some of our common North American species that have developed local races or varieties, we observe a lack of pubescence in the forms inhabiting moist, shady localities and a great increase in the density of the delicate hairs constituting the pubescence in the xerothermal forms. One example, the common circumpolar *Formica fusca*, must suffice. The typical form of this ant and its vars. *gelida* Wheeler, *neorufibarbis* Emery and *subœnescens* Emery are found only in rather damp, shady places in the far north or at high elevations, and have very short, feebly developed pubescence, while the much more pubescent vars. *neoclara* Emery, *marcida* Wheeler and *argentea* Wheeler are peculiar to the xerothermal slopes of the Rocky and Sierra Nevada Mountains. In even dryer and warmer localities these forms are replaced by the still more pubescent vars. of *F. cinerea* culminating in the subsp. *pilicornis* Emery, in which even the eyes are pubescent. *Formica fusca* var. *subsericea*, which is intermediate between such forms as the typical *fusca* and the vars. of *cinerea*, is the form everywhere common in the Atlantic and Middle States, in open woods and pastures where there is a moderate amount of moisture and sunlight. In Eurasia a very similar series of varieties occurs in similar correspondence with moist, moderate and extremely xerothermal conditions. (*F. fusca s. str.* and the forms *picea*, *gagates*, *glebaria* and *F. cinerea* with several varieties). Many other examples of this peculiar increase of pubescence and pilosity in ants, with an increase in the aridity and insolation of their habitat might be cited, but a more exhaustive treatment of the subject would consume much time, and, I fear, prove to be rather wearisome to my readers.

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# ON THE POISONS OF PLANT-LICE.*

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Although applied entomology has made enormous progress during recent years both in its scope and importance, we cannot deny that it has hitherto moved only in certain restricted paths and is therefore in danger of becoming one-sided, for the subject is taken up at present almost exclusively with a study of life-histories, with parasites and the empirically ascertained methods of combatting injurious species.† Thus it has come about that up to the present time we know very little concerning the secretion of poisons by the sucking plant-parasites and the effects of these poisons on the plants. Most attention has been paid to this question by those who have investigated the origin of plant galls. Hence it may be of interest to record some investigations which I have made on the poisons of plant-lice.

In addition to the bacterial poisons we may distinguish those of certain animals (snakes, scorpions, bees, etc.) which are characterized only by certain pecularities such as the lack of an incubation period. These animal poisons have been best studied in snakes. But there are also some researches on the poisons of arthropods (spiders, myriopods, insects). The attempt, however, has hardly been made to investigate carefully the poisons produced by the plant parasites, especially by the plant lice.

The toxins of bacteria and fungi and the animal poisons have the property of hæmolyzing, or dissolving the red pigment (hæmoglobin) of the blood corpuscles of mammals, and we therefore speak of the hæmolysis of the toxins and of animal poisons. Under their influence a dilution of red blood corpuscles in physiological salt solution takes on a clear, transparent, red color like that of lac. The poison of a particular species, however, will hæmolyze only the red blood-corpuscles of particular species of mammals, namely, those which are susceptible to the poison in question; the red blood-corpuscles of other

*Translation by W. M. Wheeler.

†J. Dewitz, Die Physiologie in der Schadlingsforschung. Trans. Second Ent. Congress 1912 pp. 234-244; The Bearing of Physiology on Economic Entomology. Bull. Ent. Research, Vol. 3, 1912, pp. 343-354.

mammals being only slightly or not at all affected. Thus the red blood corpuscles of the rabbit and rat are very sensitive to the poison of the house-spider ("Kreuzspinne," *Araneus diadematus* Clerck) and undergo complete hæmolysis, those of the mouse, man and goose are less sensitive and in the case of the guinea pig, horse, sheep and dog even great quantities of the poison do not produce hæmolysis.* It is this peculiar property of the poisons, known as hæmolysis, that I have begun to investigate in plant lice. My work has been carried on with an unidentified species of plant-louse living on *Pelargonium*, the hæmolytic experiments being performed in the traditional manner.† Among the animals investigated the red blood corpuscles of the ox were found to be sensitive to the poisons of the plant-louse.

The plant lice were triturated in a certain quantity of physiological salt solution (0.8 per cent) or in a mixture of glycerine and physiological salt-solution and placed for 24 hours in the ice-chest. Then, after filtration, the extract was used. On the other hand, I obtained a solution of defibrinated ox blood, drawn off under aseptic conditions, of 5 per cent solution. This was centrifuged, the liquid being thrice replaced with physiological salt solution, which finally gave a 5 per cent dilution of red-blood corpuscles. This dilution was mixed in variable quantities with plant-louse extract in small tubes, such as are used for serum investigations. Then the tubes were warmed in the thermostat for two hours at 37°C. and placed over night in the ice-chest to obtain the sedimentation of such blood-corpuscles as were not dissolved. At the same time control experiments were carried on in such a manner that the control tubes were heated and placed in the ice-chest together with the tubes containing the extract. In these control experiments the plant louse extract was replaced by a corresponding amount of the physiological salt-solution or of a mixture of physiological salt-solution and glycerine.

It was found that the warm dilutions of the extract hæmolyze the blood-corpuscles of the ox and that this "hæmolysis"

*Hans Sachs, Zur Kenntnis des Kreuzspinnengiftes. Beitr. Chem. Physiol. u. Pathol. (Hofmeister) Bd. 2, 1902, pp. 125-133.

†Unfortunately, I am unable at the moment to give the scientific name of this plant-louse.

takes place even at ordinary temperatures with the undiluted extract, as shown in the following example:

An extract was manufactured by triturating 0.5 gr. of plant-lice in 5 ccm. of a mixture of physiological salt-solution and glycerine in equal parts. In the dilutions of the extract used 1 cm. of physiological salt-solution contained the following amounts of extract:

1. 1 ccm. phys. salt-solution contained 1/12.5 ccm. Extr.
2. 1 " " " " 1/25 ccm. Extr.
3. 1 " " " " 1/50 " "
4. 1 " " " " 1/100 " "
5. 1 " " " " 1/200 " "

1 ccm. of the diluted extract was mixed with 1 ccm. of the 5 per cent blood dilution. Nos. 1, 2 and 3 gave complete hæmolysis. In No. 4 a small portion of the blood-corpuscles remained undissolved and in No. 5 the hæmolysis was incomplete. In the control tubes no hæmolysis occurred.

From this experiment and from another performed with the same sample of extract, which gave the same results, it is possible to make the following computations concerning the hæmolytic effect of plant-louse poison on the red blood corpuscles of the ox.

In 5 ccm. of extract there were 0.5 gr. of plant-louse matter or 0.1 gr. to 1 ccm. of extract. In 1/200 ccm. of extract there was therefore 0.0005 gr. of plant-louse matter. This 0.0005 gr. brought about a partial solution of the red corpuscles in 1 ccm. of a 5 per cent dilution of blood or the solution of the red-corpuscles of 0.05 ccm. of the undiluted blood of the ox. A complete solution of the red-blood corpuscles of 0.05 ccm. of the undiluted blood of the ox did not, however, take place till 1/50 ccm. of the extract or 0.002 gr. of plant-louse matter was used. In other words, 1 gr. of plant-louse matter will completely dissolve the red-blood corpuscles of 25 ccm. of undiluted blood or 40 gr. will dissolve a litre of blood.

The hæmolytic power of "aphidolysin," as we may call the substance, is therefore weaker than the poison of the house-spider ("arachnolysin"),* since 0.000028 gr. of this substance completely dissolves the red blood corpuscles of 0.05 ccm. of the undiluted blood of the rabbit (i. e. 1.4 gr. dissolves

*Hans Sachs *loc. cit.*

2.5 litres or 0.56 gr. will dissolve 1 litre). But we may say that perhaps by further search mammalian blood corpuscles may be found, which are more sensitive to the poison of the plant-louse I have used than the blood of the ox.

Another point also deserves emphasis. Although a hæmolytic poison is found in the organism of the plant-louse, we are unable at present to name the part of the body in which it occurs. This is also true of the hæmolytic experiments which have been performed on the house-spider, since in this case also the whole spider was triturated. The case of the hæmolytic experiments on the poison of honey bees, however, is different, since the sting together with the poison sac was extracted, and operations were therefore carried out on the poison organ alone.*

*Conf. J. Morgenroth u. U. Carpi, Ueber ein Toxolecithid des Bienengiftes. Berl. Klinisch. Wochenschrift. Jahrg. 43, 1906, pp. 1424-1425.

# A SYNOPSIS OF THE APHID TRIBE PTEROCOMMINI.

By H. F. Wilson,
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As in all other groups of the *Hemipterous* family *Aphididæ* the species grouped under the tribe name *Pterocommini* have been greatly mixed by different writers and as a result much confusion exists. In this paper the writer hopes to eliminate at least a part of this.

All the known species commonly feed on willows and poplars; one species is recorded as also being found on maple. Three species (*P. salicis*, *populea* and *flocculosum*) are recorded from Europe and five from America (*P. populea*, *smithiæ*, *flocculosum*, *bicolor* and *salicis*). The writer has never found the last nor has he seen specimens collected in this country. In all ten species have been described as follows:

1758 *Pterocomma* (*Aphis*) *salicis* Linn.
1843 *Pterocomma* (*Aphis*) *populea* Kaltenback.
1879 *Pterocomma pilosa* Buckton.
1842 *Pterocomma* (*Aphis*) *salicti* Harris.
1862 *Pterocomma* (*Lachnus salicola*) Uhler. New name for *Aphis salicti*.
1879 *Pterocomma* (*Chaitophorus*) *smithiæ* Monell.
1887 *Pterocomma* (*Melanoxanthus*) *flocculosus*. Weed.
1891 *Pterocomma* (*Cladobius*) *beuhahensis cockerell*.
1909 *Pterocomma* (*Cladobius rufulus* Davidson.
1910 *Cladobius lanthanæ* Pass (Koch) Henrich.

## *Generic Synonomy.*

Aphidologists in general have divided the species of this tribe into two groups based as a rule upon the structure of the nectaries, although Buckton erected the genus *Pterocomma* for his species *P. pilosa* on what he thought was a peculiar wing structure. (Pergande[30] believes this apparent character due to a fold in the wing.) Those species having swollen nectaries have been placed in one genus and those having cylindrical nectaries were placed in another. Such a distinction was also made by the writer in 1909, but after having further studied the group I am of the opinion that such a division is illogical and if a division is necessary each species should form a different genus. It, therefore, seems more practical to confine all the species to a single genus.

The genus name *Cladobius* found by Koch, 1857, was previously used in *Coleoptera*, 1837. Passerini, 1860, suggested a new name, *Aphioides*, but the writer believes that this is a

contraction or misprint of *Aphidioides* which was also previously used in the *Hemiptera* and must, therefore, give way to *Pterocomma*, provided by Buckton for his species *pilosa*, and which the writer believes is the same as *Aphis populea* Kalt. Previous to the establishment of this genus Buckton used Melanoxanthus to cover *Aphis salicis* of Linnæus and this name would be valid if it had not already been used in the Coleoptera. Schouteden 1906 uses *Melanoxantherium* in place of *Melanoxanthus*, but the writer is of the opinion that *Melanoxanthus* falls before *Pterocomma*. Kirkaldy[16] provides the name *Aristaphis* in place of *Cladobius* and *Aphioides*, apparently considering these names to be preoccupied.

The synonomy of the genus would then read:

*Pterocomma* Buckton.
*Aphioides* Passerini.
*Cladobius* Koch.
*Melanoxanthus* Buckton.
*Melanoxantherium* Schout.
*Aristaphis* Kirkaldy.

*Characters of the tribe and genus.*

Antennæ with six segments and reaching to near the base of the abdomen. Wings normally with venation as in Aphis. Nectaries short, but clavate. Cauda short and broadly rounded at the tip as in *Lachnini*. Entire body, antennæ and legs, covered with long hairs as in the *Lachnini*. As has already been pointed out by Oestlund, this group appears intermediate between the *Chaitophorini* and the *Lachnini*. Their habits and actions being in different ways similar to both.

A KEY TO THE SPECIES.*

1. Nectaries with diameter of opening at tip not greater than the smallest part of the nectary.....3
2. Nectaries with diameter of opening at tip greater than the smallest part of the nectary.....4
3. Distal end of nectaries abruptly constricted to a small opening; flange wanting **P. flocculosa**
   Distal end of nectaries not abruptly constricted. Nectary swollen in the middle and tapering to a small opening at the tip. Light flange present.... **P. salicis**
4. Nectaries short and stout, length not more than twice the greatest diameter **P. smithiæ**
   Nectaries more than twice as long as the greatest diameter.
5. Nectaries clavate and twice as long as the hind tarsi.....**P. bicolor**
   Nectaries appearing cylindrical or clavate and about equal in length to the hind tarsi.....**P. populea**

*Prof. C. P. Gillette, of the Colorado Agricultural College, kindly assisted in the preparation of this key.

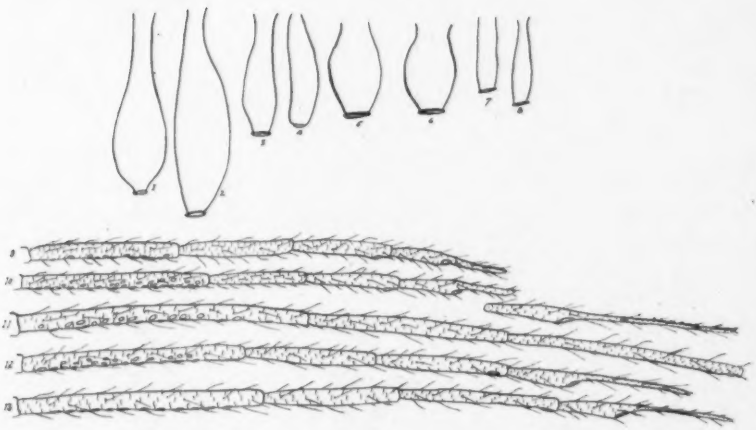

Figure 1, Nectary of *P. salicis;* Figure 2, Nectary of form found in U. S. (bicolor? salicis?) possibly new. Figure 3, Nectary of *P. bicolor;* Figure 4, Nectary of *P. flocculosa;* Figures 5 and 6, Nectaries of *P. smithiæ;* Figures 7 and 8, Nectaries of *P. populea;* Figure 9, antennæ of *P. smithiæ;* Figure 10, antennæ of *P. populea;* Figure 11, antennæ of *P. flocculosa;* Figure 12, antennæ of *P. bicolor;* Figure 13, *P. salicis*.

**Pterocomma salicis** Linn.

Synonomy: Aphis salicis, Linn. Reaum., Fabr., Schrank, De Geer, Kalt.
*Melanoxanthus salicis* Linn (Buckton).
? *Melanoxanthus salicis* Linn (Weed).
? *Melanoxanthus salicis* Linn (Packard).
? *Melanoxanthus salicis* Linn (Osborn).
? *Melanoxanthus salicis* Linn (Cowen).
*Melanoxantherium salicis* Linn (Schouteden).
? *Melanoxantherium salicis* Linn (Gillette).
*Melanoxantherium salicis* Linn (Wilson).

Since this species does not seem to occur in America it is not possible to secure a description from live material. A detailed description of what appears to be this species is given by Kaltenback and Buckton, figures accompanying the latter. Buckton's description is included here with additional notes made by myself from material on slides and in alcohol.

*Apterous viviparous female.*

| | Inch | Millimeters |
|---|---|---|
| "Size of body | 0.150 x 0.80 | 3.81 x 2.02 |
| Length of Antennæ | 0.080 | 2.02 |
| Length of cornicles | 0.015 | 0.38 |

"Very large, long oval, abdomen pointed. Dull sooty-black or greyish black, with a faint greyish medial stripe. Prothorax with a blunt tooth-like process on each side. Two broad pale grey patches on each side of the first abdominal ring—smaller patches on each side of the succeeding rings, those at and below the insertions of the cornicles being the largest. Antennæ orange red. The seventh joint small, hardly equal to the sixth. The cornicles bright orange, skittle-shaped, with dilated mouths; very short. Legs orange, with dark tibial joints and tarsi. The whole insect pilose. The underside is of obscure greyish-green. Rostrum long, reaching to the third coxæ. The young insects are black and prettily streaked with grey. Their rostra are longer than those of the adult."

*Winged viviparous female.*

| | Inch | Millimeters |
|---|---|---|
| "Expanse of wings | 0.400 | 10.16 |
| Size of body | 0.120 x 0.050 | 3.04 x 1.27 |
| Length of antennæ | 0.080 | 2.02 |
| Length of cornicles | 0.020 | 0.50 |

"Very large, greyish black, pilose. Antennæ short, having all joints black except the third and fourth, which are orange. Abdomen with two or more grey dorsal patches. Cornicles bright orange. Legs as in the larvæ. Eyes dark brown. Wings ample." "All veins are black and strongly marked."

The writer finds that the antennæ reach to the middle of the abdomen and that the third segment is the longest. From 14 to 20 round sensoria, irregularly placed on the inner side, occur on the third segment. The wings have dark veins as indicated, but hardly appear different from those of other species. The nectaries are the distinguishing characteristic as they are quite distinct in shape. See drawings.

**Pterocomma flocculosa** (Weed) [38].

*Synonomy:*

Melanoxantherium flocculosus (Weed) [33a, 24].
Melanoxantherium flocculosum (Weed) Schouteden.
Melanoxantherium flocculosum (Weed) Gillette.

That this species commonly occurs in Europe is shown by the fact that the writer has received specimens both from Russia and France, and Schouteden has recorded it from Belgium.

This species has never been collected by myself and it apparently does not occur on the Pacific Coast. For this reason color notes are taken from the original descriptions and the additional notes were made from specimens collected in Colorado and Maryland and mounted on slides.

"*Oviparous Female.*—Body 3-5 mm. long by 2 wide across middle of abdomen; antennæ 2-3 mm. long.

"General color dull, yellowish-brown, with a longitudinal row of indistinct black spots on each side of dorso meson; cornicles bright orange red, antennæ dusky, except basal portion of third joint, which is yellowish brown; legs dusky, with basal portion of femora, and sometimes more or less of tibia, dark yellowish-brown. Body, legs, and antennæ pilose; Joint III of antennæ long, but shorter than IV plus V, which are subequal; VI and VII each rather long, the latter the longer of the two. Cornicles long for this genus; swollen in the middle.

"*The Egg.*—Length, 1-2 mm.; oblong oval, coated with a thin gray substance like that on the egg of M. salicis; deposited on the bark, about the buds and axils, especially where the surface is roughened. Later he also describes what he believes to be the wingless male."

*Apterous viviparous female:* As a rule among the species of this group the apterous forms are almost exactly alike except in size and one would expect this form to resemble very closely in color markings, the oviparous female. Observations made from a slide containing several apparently apterous forms show the third antennal segment with about 14 round sensoria lying in a more or less regular line along the inside edge. In the alate form there are from 17 to 25 on the third segment. Along each side of the body may be found, one to each segment, a row of the thick short tubercles. Nectaries long and swollen, but sides tapering gradually and not suddenly bulged as in *P. salicis.* Opening at tip small and apparently without a flange. Entire body and legs covered with long hair.

*Measurements and Length of Body.*—3.6 mm.; width 1.5 mm. Length of antennal segments, III, 0.75 mm.; IV, 0.51 mm.; V, 0.5 mm.; VI, 0.22 mm.; spur 0.28 mm. Total length 2.65 mm. Length of nectaries, 0.4 mm.

*Alate viviparous female:* Body large, broadly ovate,antennæ reaching the center of the abdomen. Antennæ rather slender and with the third segment bearing from 17 to 25 round sensoria along the inner side. Wings normal, veins clear. Abdomen probably with dentate tubercles on sides, but not visable on specimens at hand. Nectaries of shape indicated in drawings.

Measurements: Length of body, 3.28 mm.; width across abdomen, 1.5 mm. Length of antennal segments, III, 0.79 mm.; IV, 0.51 mm.; V, 0.62 mm.; VI, 0.26 mm.; spur, 0.43 mm. Length of nectaries, 0.4 mm. Length of wing, 4.64 mm.

**Pterocomma bicolor** (Oestlund).

*Synonomy:*

*Melanoxanthus bicolor* (Oestlund).
*Melanoxanthus bicolor* (Oest.) Weed.
? *Melanoxanthus salicis* (Linn.) Weed.
? *Melanoxanthus salicis* (Linn) Packard.
? *Melanoxanthus salicis* (Linn) Osborn.
? *Melanoxanthus salicis* (Linn) Weed.
? *Melanoxanthus salicis* (Linn) Cowen.
*Melanoxantherium salicis* (Linn) Gillette.

In America there are two types of nectaries among the specimens designated as *Melanoxantherium salicis* Linn. One of these, as indicated in the accompanying drawings, the writer considers to be the one above indicated. For lack of proper evidence in rearing specimens the writer also considers the other type indicated as being a form of this species. However, later investigations may show the two to be from separate species. Certainly it is not *Aphis salicis* of Linn. for the writer has nineteen specimens of this group from France and Russia labeled *Melanoxanthus salicis* Linn. and the nectaries are quite distinct from any found on specimens collected in this country. It would seem then that the species *Pterocomma salicis* Linn. does not occur in America and the one or more species so determined are something else.

*Alate viviparous female:* General color, brownish, tinged with yellow. Antennæ with first two segments and the distal portions of 3 and 4, opaque, bases of third and fourth lighter with a yellowish tinge, fifth and sixth segments black. Head and thorax shining dark brown. Abdomen reddish brown with the dorsal lobes with dusky patches and a light brown median line on the dorsum. Legs yellow at the base of each part and dusky towards the ends, tarsi black. Nectaries

yellow with tips slightly dusky. Cauda black, entire body quite hairy and lightly covered with white powdery wax. Antennæ with from 20 to 25 round sensoria along the inner edge. The prothorax bears a single pair of dentate tubercles placed one on each side. Similar tubercles are also found on each segment of the abdomen. Wings with normal venation, nectaries about twice the length of the tarsi and swollen towards the ends. Just back of the flanged tip they are strongly constricted. Cauda broadly angular.

*Measurements:* Length of body 4.1 mm.; width 2.3 mm. Length of Antennal segments, III, 0.6 mm.; IV, 0.36 mm.; V, 0.35 mm.; sixth and spur, 0.5 mm. Length of nectaries, 0.59 mm.; Cauda, 0.34 mm. Wing expanse, 9.89 mm.

*Apterous viviparous females:* General color reddish brown, antennæ colored as in the alate form. Head chocolate brown and thoracic lobes slightly lighter, but darker than the abdomen. Abdomen with a series of dark spots or splotches on the dorsum and separated in the middle by a light brown median line. Similar spots may be found on the sides of the abdominal segments. A row of dentate tubercles occurs along side of the body, each abdominal segment and the prothorax having one on a side. Antennæ yellowish brown at the base and shading to black at the tip. Legs yellowish brown with the tips of the tibia and femora dusky. Tarsi black. Nectaries yellowish brown, slightly dusky at the tip. Cauda dusky brown and broadly angled.

*Measurements:* Length of body 3-7; width across abdomen, 1.71 mm. Length of antennal segments, III, 0.61 mm.; IV, 0.285 mm.; V, 0.34 mm.; VI, 0.9 mm.; spur, 0.28. Total length, 1.88 mm. Length of nectaries, 0.428 mm.

**Pterocomma populea** Kalt.

*Synonomy:*
*Aphis populea* Kaltenback.
*Cladobius populeus* (Kalt) Koch.
*Aphioides* (*Cladiobus*) *populeus* Pass.
*Pterocomma pilosa* Buckton.
*Cladobius populeus* (Kalt.) Lichtenstein.
*Cladobius populeus* (Kalt.) Mordwilko [1-2-3].
*Cladobius populeus* (Kalt.) Del geurcio.
*Cladobius populeus* (Kalt.) Pergande.
*Cladobius beulahensis* Cockerell.
*Cladobius populeus* Henrich.
*Cladobius rufulus* Davidson.
*Pterocomma pilosa* (Buckton) Wilson.
*Melanoxantherium rufulus* (Davidson) Essig.

*Alate viviparous female*: General color brown, but appearing grayish brown because of a covering of white waxy powder. Head brownish black, antennæ dusky to dark with the bases of the first to fourth segments opaque yellow or white. They extend to the base of the abdomen. Eyes red and rather prominent. Thorax shining amber to brownish black; wings normal; legs opaque brown. Prothorax with a single dentate tubercle on each side. Abdomen amber colored, grayish green below and dark brown above. Usually with a series of transverse bars on the dorsum broken down the center by a transverse white line. Also a series of black spots, one to each segment along the side and with a short stout tubercle in the center of each spot. Nectaries light opaque brown, dusky at the tip. Cauda yellowish-brown at base, dusky at tip. Body stout, abdomen broadly ovate. Antennæ reaching to base of abdomen, third segment along the outer edge. Wings normal with the median vein twice forked. Nectaries about as long as the tarsi and rather slender but swollen towards the tip. They are constricted just back of the tip, which is broadly flanged. Cauda short and angular. Entire body thickly set with black hairs.

*Measurements:* Length of body 3.7 mm.; length of antennal segments III, 0.65 mm.; IV, 0.4 mm.; V, 0.4 mm.; VI and spur, 0.6 mm. Total length 2.15 mm. Length of nectaries, 0.39 mm.; length of cauda, 0.4 mm. Wing expanse, 9. mm.

*Apterous viviparous female:* General color reddish-brown, but appearing more or less gray on account of the white waxy powder which covers the entire body, body oval, tapering towards the ends. Entire body covered with hairs. Above, the abdomen has a narrow white median line along the dorsum and a series of narrow transverse white lines which separate the segments. Along each side of the abdomen may also be found a series of black spots, one to each segment and in the center of each a denate tubercle. Antennæ with first two segments dusky or black; third segment opaque with a tinge of light brown, remaining segments shading from dusky to black toward the tip. Third segment without sensoria, fifth with one large near the distal end and sixth with one large and a series of small sensbria at the base of the spur. Legs with coxæ and base of femora light yellow, tibiæ and tarsi dark

brown to black. Nectaries shorter than in the alate form and individuals taken at certain times of year with apparently cylindrical nectaries. The normal shape, however, is slightly swollen as seen in the illustration. Cauda short and broadly angular.

*Measurements:* Length of body, 3.3 mm.; width of abdomen, 1.7 mm. Length of antennal segments, III, 0.53 mm.; IV, 0.35 mm.; V, 0.35 mm.; VI, with spur, 0.53 mm. Total length, 1.92 mm. Length of nectaries, 0.34 mm.

The oviparous females resemble the *Apterous viviparous* forms so closely, except that they are larger that a separate description is not necessary. The males resemble the alate viviparous forms closely, but are much smaller. These two forms are quite common on the twigs and leaves of poplar along the streams of the Pacific Coast during October and November.

The *eggs* which are deposited about the base of the buds are green at first, later turning to a shining black. They are elongate oval in shape and measure about 1 mm. in length.

**Aphis salicis** Harris.

*Aphis salicis* Harris (Walsh).
*Melanoxanthus salicis* (Harris) Oestlund.
*Melanoxanthus salicis* (Harris) Weed.
*Cladobius salicis* (Harris) Davidson.
*Cladobius salicis* (Harris) Essig.
*Lachnus salicicola* Uhler, Thomas, Packard, Osborne.

The writer believes that on account of the short description given by Harris that this species is not valid and that the notes and records in most cases refer to *Pterocomma smithiæ* Monell.

In the third edition of Harris' "Insects of Mass." Uhler proposes to use *Lachnus salicicola* for *Aphis salicti* and from that date a number of writers have used that name.

**Pterocomma smithiæ** Monnell.

*Synonomy:*
*? Aphis salicti* Harris.
*Chaithoporus smithiæ* Monell.
*Chaitophorus smithiæ* (Monell) Thomas.
*Melanoxanthus smithiæ* (Monell) Weed.
*Melanoxantherium smithiæ* (Monell) Gillette.
*Melanoxantherium smithiæ* (Monell) Davis.

This is undoubtedly the same species as *Aphis salicti* Harris, but his description is too meager to determine the species

with any degree of certainty and notes and records made under this name and under that of *Lachnus solicicola* Uhler could not have been based upon definite knowledge of the species in question. On the other hand, *smithiæ* is a definitely determined and well known species, the validity of which is unquestionable. It is commonly found on willow and poplar in Canada, Mexico and the United States. It has also been recorded from Maple by Weed, and I have specimens in my collection from privet hedge, Santa Crux, Mexico, by F. C. Bishop.

*Apterous viviparous female:* General color black and brownish-yellow, but all specimens have a bluish-black appearance because of the whitish powder found covering the body. Antennæ dusky at base, third and lower half of fourth segments yellow; remaining proportions dusky to black. Legs with coxæ femora and basal two-thirds of tibiæ brown, outer portion of tibiæ and tarsi black. Nectaries yellow. Antennæ shorter than in other species of the group and more nearly like those of the *Lachninæ*. Apparently without sensoria on the third segment. Abdomen with a row of broad short tubercles along each side. Nectaries short, swollen in the middle and contracted at both ends. Opening widely flanged. Cauda short and broadly rounded.

*Measurements:* Length of body, 2.8 mm.; width, 1-5 mm.; length of antennal segments, III, 0.5 mm.; IV, 0.28 mm.; V, 0.26 mm.; VI, 0.14 mm.; spur, 0.18 mm. Total length, 1.5 mm. Length of nectaries, 0.26 mm.

*Alate viviparous female:* General color black and brownish-yellow, but appearing bluish on account of the white waxy covering found over the entire body. Antennæ with two basal segments dusky-black. Third segment yellowish at base and dusky toward tip, remaining segments dusky to black. Legs with coxæ, femora and basal half of tibiæ yellow; remaining portion or tibia and tarsi black. Wing venation normal, veins slightly darkened. Nectaries yellow, tinged with brown. Cauda black. Antennæ extending slightly beyond the third pair of legs, and third segment bearing from 19 to 26 circular sensoria irregularly placed along the inner side. Thorax and abdomen with a row of thick short tubercles along each side. Nectaries short, swollen in the middle and strongly

constricted at both ends. Opening at tip large and widely flanged. Cauda short and broadly rounded.

*Measurements:* Length of body, 3 mm.; width, 1.2 mm. Length of antennal segment, III, 0.44 mm.; IV, 0.26 mm.; V, 0.27 mm.; VI, 0.14 mm.; spur, 0.14 mm. Total length of antennæ, 1.42 mm. Length of nectaries, 0.3 mm. Length of wing, 4.7 mm.

*Cladobius lanthaniæ* (Pass) Koch (Henrich).

Henrich lists *Aphis lantanæ* Koch under the above name and refers it to Passerini. The writer has never seen this species, but from the description given by Koch and his figures I am of the opinion that it does not belong here.

He also records a species under the name of *Cladobius ? salicis* (m) from trauerweide (Weeping Willow).

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# THE DISTRIBUTION AND ABUNDANCE OF THE OX WARBLES, HYPODERMA LINEATA AND H. BOVIS IN THE UNITED STATES.

By F. C. Bishopp,
Bureau of Entomology.[1]

Considering the importance of the ox warbles as pests of cattle, it is odd that so little is known by entomologists regarding their distribution and relative abundance. It is well known that *H. lineata* is widely distributed in this country, but the fact that there are areas where this species is almost or entirely absent has not been recognized.

That the so-called European ox warble, *H. bovis*, is to be found over a considerable area in the northern portion of the United States has just been determined through investigations conducted by us during the past two years. In fact, this species has not been reported to occur in the United States except in a single instance. In this case, Prof. C. W. Johnson[2] reared this species from larvæ collected at Manchester, Vermont, in June, 1910. In the early work of Prof. C. V. Riley,[3] in which a considerable number of larvæ from various parts of the country were examined, not a single specimen of *H. bovis* was obtained. In 1905, Prof. Aldrich[4] states that *H. bovis* is not positively known from North America. In 1912, Dr. S. Hadwen[5] announced the common occurrences of *H. bovis* at Agassiz, B. C., and in 1914 Dr. C. Gordon Hewitt[6] reported that he had seen specimens of this species from Nova Scotia, Quebec, Ontario, Alberta, and Saskatchewan, thus indicating a distribution from the Atlantic to the Pacific in Canada.

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[1]Published by permission of the Chief of the Bureau of Entomology.

[2]Johnson, C. W., 1910, Psyche XVII, p. 231. December.

[3]Riley, C. V., 1892, Insect Life, IV, pp. 302-317, 12 Figs.

[4]Aldrich, J. M., 1905, A Catalogue of North American Diptera. Smithsonian Miscl. Coll. XLVI, No. 1444, p. 416.

[5]Hadwen, S., 1912, Bull. 16, Health of Animals Branch, Canada, Dept. Agr. 20, pp. 9 pls.

[6]Hewitt, C. Gordon, 1914, Can. Ent., XLVI, pp. 1–2.

DISTRIBUTION AND ABUNDANCE OF *Hypoderma lineata*.

It appears that this species is to be found in every State in the Union, although, as has been indicated, there is considerable difference in its abundance in different sections. During our inquiry into the distribution of ox warbles during the last two years, we have obtained specimens from thirty-one of the States, but there is no reason to suppose that the species is not common in all of the others. A total of about 140 lots was obtained during this investigation as a result of personal collections and specimens sent in by numerous correspondents.

In general, it appears that *H. lineata* is more abundant in the Southern and Central Western States than elsewhere in the country. However, the presence of the two species combined in Vermont and New Hampshire probably gives a heavier infestation there than is to be found elsewhere in the country.

We have found the species to occur commonly at all altitudes, from sea level to 9,000 feet. As is indicated by its wide distribution, it is also to be found in the humid, semi-arid and arid regions. Our inquiry thus far does not indicate that annual rainfall has any material effect on the abundance of the species. It is possible, however, that by closer study we shall find that the rainfall during the spring and early summer has a material effect on the local and annual abundance of the species.

The north-central part of the United States, including portions of the States of Minnesota, North and South Dakota, and Montana, seems to be freer from the pest than any other region. In fact, throughout considerable portions of this region ox warbles are entirely unknown. This is particularly true of those portions of North and South Dakota and western Minnesota included in the valley of the Red River of the North. An explanation for the absence of warbles from these areas is not apparent. It has been found that the species is absent from wooded regions as well as plains areas, and there is some difference in the rainfall within the non-infested region. In South Dakota it was observed that the warbles were to be found in the hilly region along the divides between rivers. Hence, it would appear that there is some relationship between the topography of the country and the occurrence of the species in that section. Prof. H. C. Severin states that he has observed this practical absence of warbles from eastern South Dakota,

and that a greater number occurs in the western part of the State. Dr. W. L. Boyd states that while warbles are rather common in southern Minnesota, he has never known an animal to become infested at the Experiment Station at St. Anthony Park. Dr. Boyd found 39% of two herds of dairy cattle, totaling 82 head, to be infested in the vicinity of Duluth. All of the specimens obtained from these herds proved to be *H. lineata*.

Although this species is present in a large percentage of the live stock in the central part of the Mississippi Valley, there is some indication that it is decreasing in numbers in this region, probably owing to the more extensive cultivation of the land and better care being given to the live stock. The heaviest infestation of this species which we have observed occurred in southwestern Texas, although it does not follow that this region is in general more heavily infested than others. Probably 75% of the cattle in the United States are more or less infested. The average number of warbles per animal ranges from one up to about one hundred. Many animals even in rather heavily infested herds, are entirely free.

The localities from which we have obtained specimens of this species are indicated on the accompanying map. Records made by other investigators are not included. These would add a large number of localities, including some of the States from which we have not obtained specimens.

### Distribution and Abundance of *Hypoderma bovis*.

As is shown on the accompanying map, this warble is rather widely distributed through the northern part of this country.[1] The north-eastern States have by far the greastet infestation, Vermont being the center of this heavily infested region. Although a considerable number of specimens of *H. lineata* were obtained from Vermont and New Hampshire, undoubtedly *H. bovis* occurs in greater numbers. This is also true of New York, and probably of Pennsylvania. St. Louis, Mo., was the

[1] The counties from which we have obtained specimens of *H. bovis* are as follows: Alabama, Lee; Illinois, Cook; Iowa, Scott; Maine, Oxford; Maryland, Garrett; Michigan, Ingham; Montana, Fergus; Missouri, St. Louis; New Hampshire, Grafton, Merrimac, Rockingham; New York, Oneida, Onondaga, Ontario; Pennsylvania, Erie, Washington; Vermont, Bennington, Franklin, Orange, Orleans, Rutland, Washington, Windham, Windsor; Washington, Jan Juan.

southernmost point from which we obtained specimens of the so-called European ox warble. However, but a single grub was collected in this locality, and on account of the fact that this is a concentration center of considerable importance it may be that the infestation was recently introduced on cattle shipped from elsewhere and will not persist. The specimen taken was found on a dairy cow in a herd on the edge of the city. A well established center of infestation occurs almost as far south as

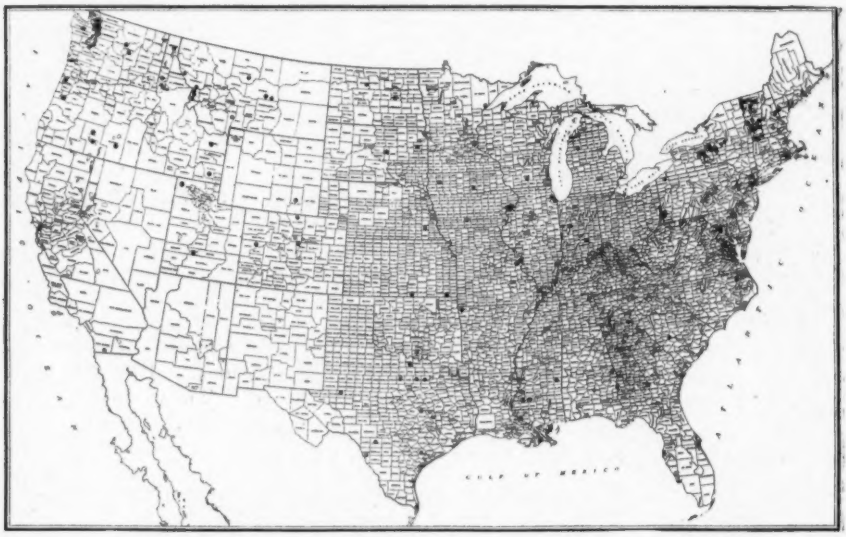

Fig. 1. Map showing the distribution of the ox warbles in the United States. The dots indicate where *Hypoderma lineata* has been collected in this investigation; the crosses indicate *Hypoderma bovis*.

St. Louis, at a point in western Maryland. This locality is in the Allegheny Mountains, and the infestation appears to extend continuously northward through Pennsylvania into New York. The correspondent who collected these specimens states that he does not know that any cattle have been brought into that locality from the north for a great many years. It was thought that possibly *H. bovis* might be best adapted to the conditions in the northern part of the country, especially along the mountain ranges. While this theory seemed to be fairly true for the eastern part of the country, it was not borne out by

findings in the West. As has been stated, Dr. Hadwen reported this species to occur commonly in eastern British Columbia, and one would expect this infestation to extend southward along the Rockies in the United States. However, only two lots of this species were obtained from the West. One of these from Waldron, Washington, consisted of one larva of *H. bovis* and five of *H. lineata*. This place is situated on an island in Puget Sound not far from the Canadian line. The other point of infestation was located at Garneil, Montana. Our correspondent there sent in two lots of warbles; the first contained one specimen of *H. bovis* and one of *H. lineata;* the second, three specimens of *H. bovis* and one of *H. lineata*. No information was secured regarding the possible mode of introduction of this species into Montana, although it is wellknown that pure blooded stock, particularly of the dairy types is brought in from the East. In the North Central States, three points of infestation were discovered. A well established infestation was found to occur at Davenport, Iowa. A correspondent at that point sent in three fourth-stage larvæ of *H. bovis* on April 26, 1915, and twenty larvæ in the same stage on May 6, 1915. No information was gained as to the possible origin of this infestation. On May 7, Mr. E. W. Laake and the writer obtained twelve fourth-stage larvæ in the back of a cow in the stock yards at Chicago, Ill. Four of these proved to be *H. bovis*. The origin of the infested animal could not be learned. The single occurrence of this species in Michigan was established through the collection of six larvæ by Dr. Shafer at East Lansing, on April 7, 1914. Two collections of larvæ from cattle at Cadillac, Michigan, by Mr. James F. Zimmer, prove to be composed entirely of *H. lineata*.

It would seem, therefore, that in the western two-thirds of the United States, *H. bovis* is to be found in rather restricted and well separated areas, although no doubt a thorough search would reveal a more general distribution than is now supposed to exist. In the Northeastern States this species predominates over *H. lineata*, both in distribution and abundance.

The writer is of the opinion that the European ox warble must have some well marked climatic barriers which have prevented its general dissemination throughout the country, as cattle, many of which are no doubt infested, are shipped annu-

ally to the Central and Southern States from New York and other States where this species commonly occurs. One explanation of this possible barrier will be found in the fact that *H. bovis* is generally later in emerging from the backs of cattle than *H. lineata*, The grubs emerging from the backs of cattle shipped to the Southern States would, on account of this later date of emergence, encounter excessively hot weather and this may account in part at least for the failure of the species to establish itself in the warmer portions of the country. It may be of interest to note that on April 23, 1914, Dr. W. E. Hinds sent in three specimens of this species from the experiment station at Auburn, Alabama. These were obtained from the back of a young bull which had recently been shipped from New York.

## ADAPTATIONS TO ARID CONDITIONS IN CERCOPIDÆ AND MEMBRACIDÆ.

By E. D. Ball.

The frog-hoppers are distinguished from other Homoptera by the fact that the larvæ envelope themselves in a mass of froth, using this no doubt as a means of protection from their enemies. Only a few species occur in the arid regions, but these are distributed through all but one of the genera occurring in the United States.

The representatives of one of these genera, the *Clastoptera*, appear to have the same froth making habits in the arid region that they have in the humid. The larvæ usually occur early in the season, however, before the air has become very dry or are restricted in distribution to the higher mountains or to exceptionally humid situations in the lower valleys. The other representatives of this group in the more arid regions apparently do not attempt to maintain froth masses exposed to the air, as none have ever been found.

In a former paper* the writer showed the unique method employed by *Aphrophora permutata* Uhl. a western relative of the pine inhabiting species of the Appalachain region. This species was found on the roots and crowns of a Composite and a Legume, where they were protected from the sun and dry air.

Since that writing the larvæ of *A. annulata* Ball has been found around the crown of *Artemisia ludoviciana* in Utah and the larvæ of *Philaronia abjecta* Uhl. on the roots and crowns of *Lupine* and *Geranium* in the mountains of Colorado. The larvæ of the other species of *Philaronia* (*P. bilineata*) occurring in the mountains of Colorado has never been found, although the adults are among the commonest of the family.

During several seasons collecting in California another species of *Aphrophora*, *A. angulata* Ball has been taken quite commonly in certain restricted areas along the coast. This species is closely related to the common *A. binotata*, common on grass and low vegetation east of the Rocky Mountains and whose spittle masses are often so abundant in the meadows as to be a nuisance. The California species was collected on

*Ohio Naturalist, I, p. 122, 1901.

willows and in low situations where grasses occur if at all in California, but no spittle masses were ever seen, although careful search was made.

Last season while collecting another rare species of Homoptera occurring in grassy places, the writer accidentally broke a leaf off from the giant Umbellifera—*Heracleum lanatum* and discovered that the enlarged sheath was full of froth and that nearly a dozen *Aphrophora* larvæ were hidden in the mass.

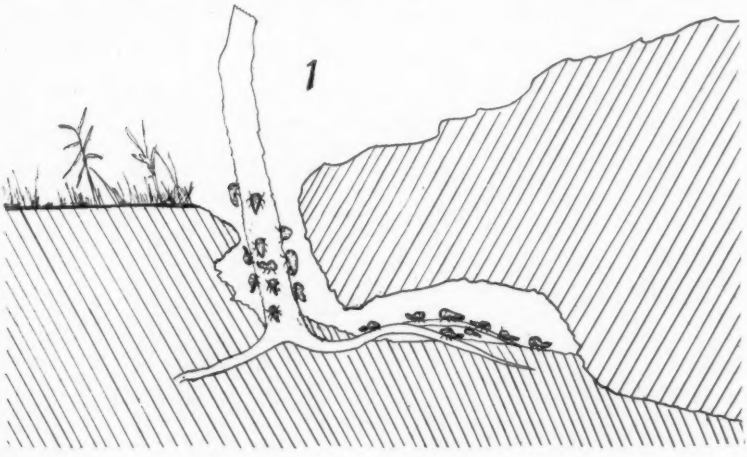


Fig. 1. An *Amorpha* stalk with membracids on roots and stalk below the ground line.

An examination of other sheathes revealed other froth masses ranging from a single larvæ up to over twenty in one case. The larvæ were of various sizes from one-third to full grown when found and a few fresh males nearby completed the identification.

The weed extends across the continent from coast to coast, but this species of *Aphrophora* has only been taken along the California coast from Los Angeles to San Francisco.

Like the other frog-hoppers, it appears to be single brooded, the larvæ appearing in March and April and the adults transforming from late April through May and living until into July and August.

The *Membracidæ* are few in number in the arid regions, especially of the more strictly tree and shrub inhabiting genera contrasted with the weed and miscellaneous feeders like the *Stictocephalinæ*. This may partly be accounted for by the scarcity of trees in these regions, but probably the climatic factor is also of importance. The fact that certain forms

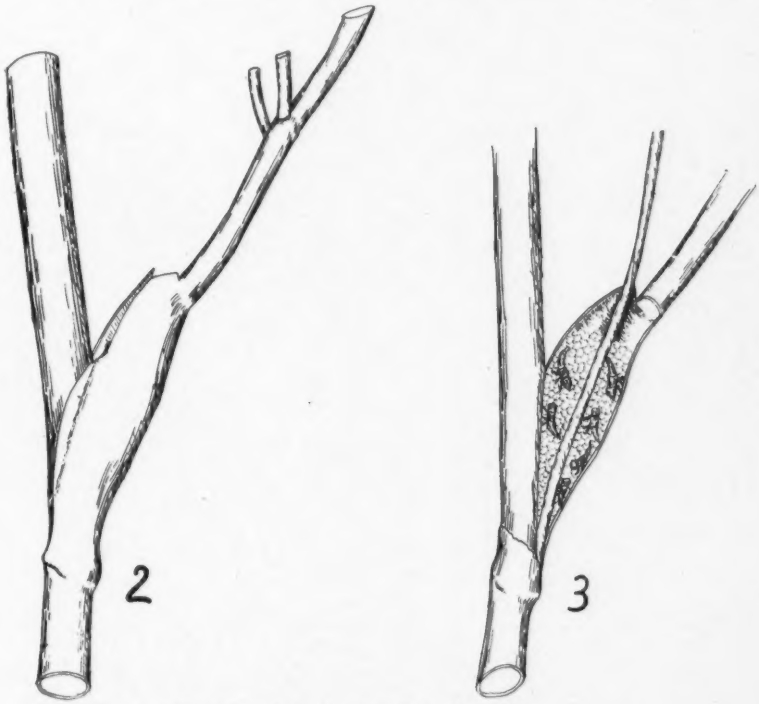


Fig. 2. A stalk of *Heracleum* showing the leaf sheath.
Fig. 3. Section of leaf sheath with larvæ of *Aphrophora* and their froth.

do not follow their respective trees into the arid region and more especially the peculiar change in habit of two eastern species mentioned below, indicate that the aridity is a limiting factor.

The larvæ and adults of *Vanduzea vestita* Godg live together in colonies on the lead plant *Amorpha canescens* Pursh in the Mississippi Valley and are often seen congregated on the

most exposed part of the plant, and are always found on the upper parts of the plants in that region. This plant also extends into the arid region, but in less numbers.

While collecting a wingless ground inhabiting Capsid on a sunny mountain slope in Colorado, the writer found a colony of *Vanduzea vestita* feeding upon the stem and roots of an *Amorpha* beneath a stone. They were as usual attended by ants, so the excavation beneath the stone and around the stem of the plant may have been made for them by the ants or may have existed previously. At any rate, there they were in numbers, larvæ and adults, in the hollow beneath the rock and in a circle around the stem beneath the ground, a very few being above the ground line.

Since that time a number of colonies have been found extending down into the ground for an inch or two and occasionally having lateral galleries. Frequently they would be found gathered around the stem for an inch above and below the ground line under clumps of *Psoralia* or *Amorpha*, where the branching clump served as a protection in itself.

*Campylenchia curvata* Fabr and *Publilia modesta* Uhl have both been found occupying similar situations under clumps and in excavations around stems of their food plants. All these observations were made in very dry hot situations, desert or dry mountain slopes for the most part. In damper situations, such as river bottoms, thickets, mountain valleys and especially in irrigated alfalfa fields *curvata* will be found on all parts of the plants.

# A NEW GENUS AND SPECIES OF ALEYRODIDÆ FROM BRITISH GUIANA.

A. L. Quaintance and A. C. Baker,
Bureau of Entomology.

We have recently received from Mr. G. E. Bodkin, Government Biologist of the Science and Agricultural Department, British Guiana, specimens of an interesting white fly, found by him March 2, 1915, on leaves of *Erythrina glauca* Wild., at the Rose Hall plantation, Berbice.

The insect is most closely related to species of *Dialeurodicus* (subfam. Aleurodicinæ) and differs in the pupa case from these principally in the presence of reduced compound wax pores, and in the character of the vasiform orifice. The genus appears to fall between *Dialeurodicus* and *Aleurodicus*.

Genus *Eudialeurodicus*, n. gen.

Forewing similar to that of *Dialeurodicus* with radius, radial sector and media retained. Vertex rounded; frons produced beyond the vertex; antennæ of seven segments. Paronychium a stout spine.

Pupa case flat, resembling *Dialeurodicus*, but with one or more pairs of reduced compound wax pores. Vasiform orifice small, the lingula included and broadly rounded.

Type *bodkini* Quaintance and Baker.

*Eudialeurodicus bodkini* n. sp.

*Egg.*—(Plate XXVI, Fig. 16), Elongate, yellowish in color, size 0.4 x 0.11 mm. Shell without markings; stalk short, attached at one side of basal end.

*Pupa case.*—(Plate XXVI, Figs 1 and 6), On the leaf the insects are located principally along the midrib and larger veins. The case is more or less hid by the copious secretion of glassy, whitish wax, occurring in two concentric rings or bands. From the margin of case all around is produced a fringe of closely placed threads of wax which basally has the form of a solid more or less vertical ring, and which persists on the leaf after removal of case. Just within this ring is usually a circle of polygonal areas which may also be present over the entire area which had been covered by the ventral surface of the case. Another secretion originates from the submarginal area of the dorsum in the form of a band or ring of amorphous white wax. This is variable in extent and in some individuals becomes a plate covering the body, the periphery being irregular, while the more central area is concave. Leaves frequented by the adults show powdery white wax.

The pupa case proper is flat, yellow in color with a large dark brown area on the thorax and also on the abdominal region. These brown areas vary in extent and may become coalescent, covering practically the entire dorsal disc. Size of case about 1.66 mm., by 1.5 mm., ovate in outline, widest caudad centre. Body segments quite distinct on dorsal disc. Margin of case, (Plate XXVI, Fig. 7), is seen under high magnification to be practically entire, though appearing incised under lower power, due to the presence just within margin of a series of small, fusiform glands, and from which delicate sutures extend mesad. On caudal segment of case is a pair of reduced compound pores, (Plate XXVI, Fig. 2), each giving rise to a long slender spine homologous apparently to the so-called "central process." A single reduced pore is usually present on the third abdominal segment well to one side of the median line, either to the right or left, more usually on the right side, (Plate XXVI, Fig. 3). We have seen no instance in which both pores were present in the same individual. The variability in position of this pore and the rudimentary condition of the pores on the anal segment indicate the intermediate status of the species between *Dialeurodicus* in which no pores are present, and *Aleurodicus* in which genus these are mostly well developed. Numerous minute pores, appearing as clear white dots, are scattered over the body, some of which occur in groups, especially on the abdomen.

Vasiform orifice, (Plate XXVI, Fig. 13), small, transversely elliptical in general outline, the cephalic margin being straight. The operculum about half fills the orifice, is transversely elongate, the sides rounded and caudal margin concave. The lingula is much shortened, broadly rounded about one-third as long as the orifice. On ventral surface of case the antennæ and legs are distinct, each of the latter terminating in a hooked spine. (Plate XXVI, Figs. 5 and 17).

*Adult* ♀.—Length from head to tip of abdomen about 2.5 mm. Forewing about 2.5 mm., long by 1.63 mm., wide, rounded, marked with small groups of dots as shown in the figure, (Plate XXVI, Fig. 8); hind wing unmarked. Hind tibia about 0.9 mm., long, hind tarsi together 0.5 mm., in length, the basal joint being about twice the length of distal; claw usual, with spine like paronychium, (Plate XXVI, Fig.15). The general color of body is yellow with brown coloration on legs, body sutures, parts of antennal joints, etc.; the tip of mentum is dark brown or blackish. Vertex rounded and armed with a row of stout spines. Frons armed with tubercles (Fig. 14). Head not showing the cone shaped extension of the vertex present in species of *Dialeurodicus*. Compound eyes "dumb bell" shaped, dark red or brown. Ocelli prominent. Antennæ (Plate XXVI, Fig. 18) of seven segments; segment I, short, cup-shaped; II, over twice as long as I, fusiform, dusky in color. Segment III, about 0.35 mm., in length, not quite as long as the four distal joints together, slender, dusky on distal fourth armed with about fifteen sensoria. Segments IV and V subequal in length as are joints VI and VII. Segments III-VII imbricated.

*Adult* ♂.—Essentially like female, though smaller; genital segment 0.5 mm., long; claspers, (Plate XXVI, Fig. 12), sickle like, about as long as the genital segment. Penis about half as long as claspers. From the segment cephalad of the genital segment arises a pair of long curved processes, extending caudad well beyond the end of anal segment, structures which we have not previously observed in the family, (Plate XXVI, Fig. 10).

Type, No. 19592, U. S. National Museum.

Described from pupae on leaves, pupae, adults, and eggs in balsam mounts, prepared by Mr. G. E. Bodkin, to whom we have pleasure in dedicating the species.

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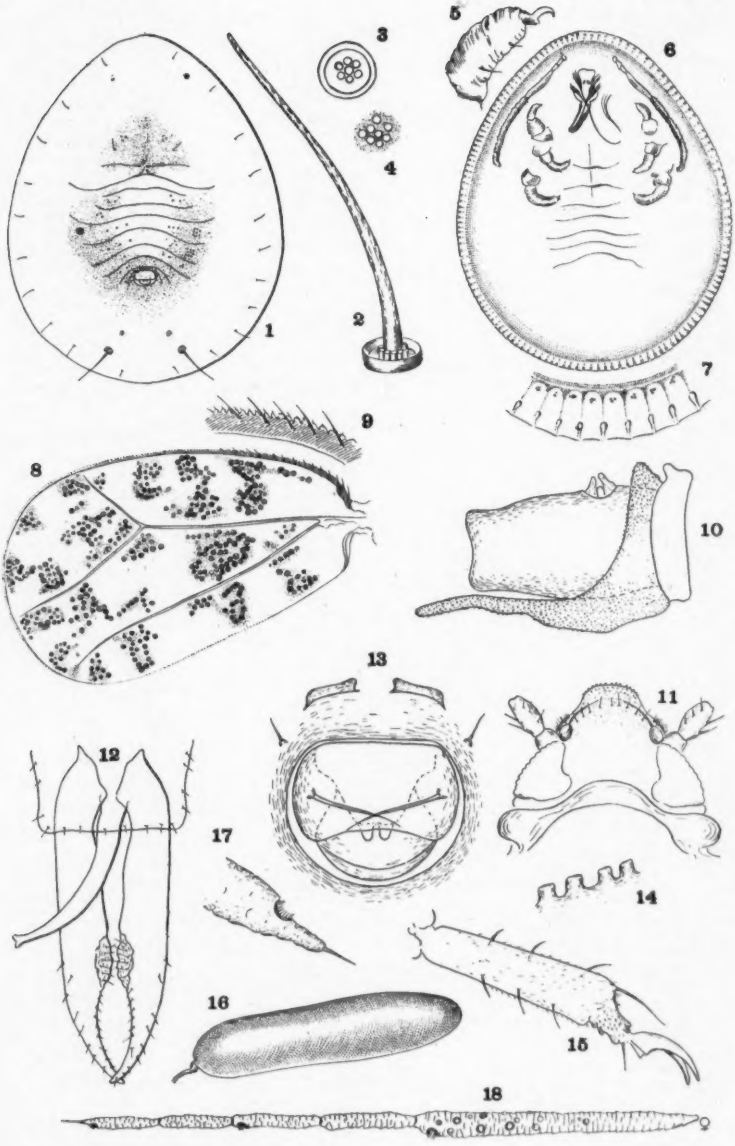
EXPLANATION OF PLATE XXVI.

Fig. 1.—Pupa case; dorsal view.
2.—Compound wax pore.
3.—Reduced compound wax pore.
4.—Clustered simple pores.
5.—Foot of pupa case.
6.—Pupa case; ventral view.
7.—Margin of pupa case.
8.—Forewing of Adult.
9.—Costal margin of forewing.
10.—Caudal portion of abdomen of male, showing appendages.
11.—Head of adult.
12.—Claspers of male.
13.—Vasiform orifice of pupa case.
14.—Tubercles on frons of adult.
15.—Foot of adult.
16.—Egg.
17.—Tip of Antenna of pupa case.
18.—Distal segments of antenna of female.




*A. L. Quaintance and A. C. Baker.*

# QUANTITATIVE ENTOMOLOGY.

C. W. Woodworth.

The best answer to the question, "What is it that we consider worth while in Entomology," is given by the record of our activities. There are innumerable descriptions of rare new species of insects. Peculiar habits or structures receive detailed consideration. Unusual inter-relationships between insects and their environment compel our attention and interest. An insect that is noticed for the first time to attack our crops or our persons is investigated with great thoroughness.

When we make textbooks we endeavor to assemble and arrange in an orderly fashion this wonderful wealth of detail. Throughout the exceptional, the unique and the unexpected are given the emphasis. All of this is right and proper. It is in this way that all sciences have been developed, but this does not constitute the final goal nor leading method of science. Finally, the predominating question becomes not what, but how much? Finally, it is a question of values. Thus in physics we have ceased to give much prominence to the mere operation of physical laws, but must measure the results with such accuracy that this science has almost become a branch of mathematics. Likewise in chemistry the wonderful advances of the subject in later years both in theoretical and technical lines depend upon the study of reactions quantitatively.

The present paper is intended as suggestions and a plea for the development of a quantitative entomology. Qualitative work must not cease nor be abated, but to it should be added the higher development of the subject which will finally come to be considered the essential portion of the science.

A beginning has already been made in nearly every department of entomology towards this quantitative method of study, enough to give us some idea of the simpler lines of procedure and of the results likely to be secured. Quantitative entomology is not therefore a wholly new idea, but is a great territory, the boundaries only of which have been explored and in the depths of which we may expect to find the chief justification for our endeavors.

Entomology is now confronted with the same condition which older sciences experienced and like them must become an exact science if it is to realize its highest development.

Along with the improvement in accuracy and detail there must come at the same time a simplification through the elimination of the non-significant details of each department of entomology and a clearer recognition of the distinctness of these departments.

### DIAGNOSTIC ENTOMOLOGY.

In no place is this need more clearly shown than in what we know as Systematic Entomology, a very utilitarian department concerned in the assigning of names to insects and in providing the means whereby these insects may be identified. Such an entomologist is a Diagnostician. His problems are numerous and difficult enough, requiring the specialization into very restricted groups, and is rendered more difficult by the fact that many have confused their work with two very different departments — classification and descriptive entomology.

Keys have been rendered unnecessarily difficult by attempts to make them conform in arrangement to supposed phyletic sequences and pages of descriptive matter in defining a new species seldom results in making its correct identification more certain and certainly makes it much more laborious.

Keys should be arranged in a manner to best facilitate identification, every other consideration should be subordinated to this end. This principle appears to be beyond controversy. How it shall be applied, that is, what form tables will finally take, is a matter that time will decide.

Two plans of arrangement are presented for your consideration, one based on dominance and the other on historic sequence.*

The latter appears to be best for the species of a genus where the commoner forms are liable to be first described and the former method for larger groups which, because of the changing views as to what they include, can be best studied according to their present rather than their historic content. Keys constructed along these lines have proven remarkably simple and workable. They are particularly good for teaching

* The paper was illustrated at this point by the keys given in the author's "Families of Insects," and "Insects of California."

purposes, since they emphasize the dominant groups and their most evident characteristics. Keys can be wisely restricted to single characters wherever possible and the use of "usually" or "rarely" in connection with a character should be rigorously excluded. Key characters should be so selected that the differentiation is most certain and evident. All differentiating characters must be definite degrees of variation.

The diagnosis of a species should be limited to differentiating characters. A great deal that finds its way into the description of a new species is descriptive and not diagnostic and is worse than useless for the purpose of identification. On the other hand, very few descriptions are exhaustive enough. Every character that rightfully belongs in the diagnosis of one species of a genus should appear in the diagnosis of every other species of that genus and each genus will have its own set of differentiating characters.

The contention is, first, that there exists in each genus a set of definite quantitatively measurable variants which constitute the diagnostic resources for that genus and that all of them should be included in each specific description, but that a distinction should be made between them for use in keys, only those most evident or tangible being employed and that the key should be arranged solely for convenience in identification.

## DESCRIPTIVE ENTOMOLOGY.

What we know as the specific descriptions of insects even in their most elaborate form are too meagre to be looked upon as fairly representing what descriptive entomology should accomplish.

For a few insects the accounts of the structure that have been published are perhaps sufficiently voluminous, but only the beginning has been made in the approach to the ideal which I wish to urge as the goal for future work.

Descriptive Entomology is concerned with, 1st, a study of size and form; 2nd, surface differentiation; 3rd, color and pattern and 4th, internal structure.

*Size and Form* should be so studied as to become expressible in terms of the dynamics of growth. We must discover and measure the intensity of the determining factors. A few

categories are already well known. We have, for instance, (a) cases where there appears to be a simple difference in the size of all parts simultaneously, (b) cases where in the ontogeny of an insect certain parts gain their growth at a different period than others and the conditions affecting general size may show most prominently in these organs and (c) cases where the tendency to abnormal growth seems limited to certain organs and the adjacent parts profit or suffer through this abnormality.

This list of categories will have to be enlarged and subdivided as investigations will show necessary until we can recognize the nature of the variation in the growth of organs or portions of the body that brings about all the differences we observe in size and form.

*Surface differentiations* result from variations in the secretion of cuticle by the individual epithelial cells and should be expressed in terms of these activities. Often a very definite relationship between the surface modifications and the form of the parts of the body may be recognized. The most evident categories are (a) where the cells over the whole sclerite or specialized organ produce a homogeneous cuticle, (b) where an equally definite relationship exists but with bordering or concentric specializations, (c) where the structural modification has relation to general body structure rather than to individual sclerites and (d) where the modification conforms to an internal structure, particularly muscle attachments.

The qualities of the surface modifications we express by a large series of Latin adjectives describing the mass effect of these cuticular differentiations. These adjectives should be redefined in terms of their ultimate structure in the individual cells and subdivided as found necessary where the same superficial appearance is the result of essentially different modifications.

The accurate quantitative statement of surface structure will become possible as soon as progress is made in the more logical study of the topographic and qualitative differentiation just suggested.

*Color and pattern*, like surface structure must be studied as the resultant from the activities of individual cells, but is not wholly a question of pigment as has already been amply shown nor wholly of epithelial activity. Our classification

and nomenclature of colors require an entire reorganization. They should be primarily based on the nature of the color reflecting substance rather than on the physiological effect of the light rays that are most evident to the eye. This is necessary before we can make any progress in a quantitative statement of color values. The topographic differentiations or patterns are subject to the same classification that have been indicated for the surface modifications and doubtless are often responses to the same phylogenetic or ontogenetic causes.

*Internal structure* may be divided into two chief divisions, the larger portion of the muscular and nervous systems whose specialization is definitely associated with details of the external structure and the remaining tissues associated with vegetative functions.

The former should be considered in connection with the skeletal parts with which they are associated and their differences in histological structure and in shape and size studied in relation to their functional requirements. When the study is carried far enough to differentiate the various types of structure there will remain the ultimate distinctions to be made by quantitative determinations.

The vegetative functions, digestion, respiration, circulation, excretion and reproduction, involve a series of structures having a more remote connection with the external environment, but nevertheless, find their best basis of classification in the effect of the external world on their individual activities, and, of course, involves a full comprehension of the details of their physiology and has relatively little to do with the external topography except in its general aspects.

All structures according to the conception here promulgated are classifiable into groups comparable with genera and species, the former distinguishable by differences of kind, the latter by differences of quantity. That descriptive entomology has before it the task of perfecting its nomenclature so as to be able to describe all differences of kind explicitly and accurately and then, by quantitative determinations can give exact descriptions of insect structure, a description which expresses the nature and character of the parts rather than their superficial appearance.

## CLASSIFICATION.

The classification of organic beings has to do with questions of phylogeny exclusively. No small amount of confusion has arisen from attempts to combine classifications and keys for identification to the detriment of both. The groups recognized by both the Diagnostician and the Systematist should be the same, but the characters and arrangement need have nothing in common. The best diagnostic characters may have little or no phyletic significance and the phylogenetic sequence of groups may introduce confusion and difficulties in identification.

The problems of phylogeny are two, the derivation of groups and the coordination of groups.

*Derivation* of groups to determine by a comparative study of the structure, substantiated wherever possible by the historic sequence of the first appearance of the groups as shown by the geological record, the underlying principle being that the complex structure was derived by the specialization of simple structures. Two groups are supposed to have a common ancestor if they resemble each other in most of their characters. The characters by which they differ are supposed to be those historically responsible for the separation of the groups. As a matter of fact groups are usually distinguishable by numerous characters, many of which are accidental or only incidentally coordinated with the historic basis of the segregation. The Systematist therefore, must search for the differentiating character, which may be internal or difficult of observation and very unsatisfactory for diagnosis, but the only one perhaps that gives a clue to the causes which brought about the separation of the groups. Differentiating characters are perhaps always differences of kind, representing alternative possibilities in growth and either a new structure in the place of an older one, or progress in the development of a structure of which there may be two possible lines of growth. Some differentiations involve no appreciable change in other parts of the body, while others are revolutionary. The former we conceive may frequently recur, giving us examples of parallel development. Many generic differences are clearly of this character. The more involved modifications give so many opportunities for variation that strict parallelism appears to be impossible.

Thus the production of wings is a specialization least liable to have occurred more than once in the history of insects, while the suppression of wings is an often recurrent phenomenon.

Again characters which are of themselves of little moment may open the way to other reorganizations of structure of highest significance. This development of complex metamorphosis may easily have occurred more than once. The male Coccidæ probably have such a mode of development following the most strict definition of the process and the hypermetamorphosis of Meloids is a further extension of practically the same kind of specialization, but the development of this mode of growth opened the way to the origin of the four largest orders.

To properly estimate the relative phylogenetic significance of characters all of these considerations must be comprehended in our classification. From this point of view no character is important in itself only in its relation to the whole organization of the members of the group.

*Coordination* of groups consists of determining which are to be considered of equal rank. This is a subject upon which there has been, and still is, two very definite tendencies. Entomologists are in most complete accord for instance as to the orders into which perhaps 95% of the species of insects belong and nevertheless, the current text books vary from 7 to 37 orders. The same tendency is seen among systematists in every group of plants and animals.

Some naturalists may have the conception that every group sprang from a single mutant pair and from the time of their mutation the new group existed. The Lepidoptera are for instance derived by common consent, from the Trichoptera, because chiefly of the almost complete conformity of the venation of certain members of the two groups, but there are at least two very different types of wings in which this perfect conformity is seen which are most easily explained by the assumption of a tendency of development seen in a series of species in one order giving rise to a series of forms in the new group in the same manner as most conceive that geographic isolation may bring about two species with parallel varieties. The variations being parallel because residual.

If this principle is accepted, as most naturalists do, the necessity of making quantitative valuations to the amount of variation separating groups is necessary. The traditional primary classification of insects is represented by the common names and was adapted by Linnaeus for his orders. In these the quality of variation is represented by the differences between bees, flies, butterflies and beetles. The practical question to be settled is whether the difference between, say an ant lion and a sialid, is of the same order of magnitude. It would seem that those who have gone to the extreme in increasing the number of orders have either ignored or rejected this principle. After wings were produced we must conceive that there was a single order, family, genus and species, that first there occurred a multiplication of species, some of which became more, and, finally, were generically different, and last of all the difference of the most remote forms represented different orders. The differences between the Orthoptera and Neuroptera most probably represents the progressive development of a whole family, rather than a great mutation of a single species and that historically there was a period where two families representing the two orders were families of the same order. A time is reached when the differences become great enough to be of ordinal value.

We must strive toward the goal where we can assign a quantitative degree of differentiation as representing family rank and another for order rank, etc. to replace our present plan of making such groups on the basis of indefinite mental impressions.

## DISTRIBUTION.

Most collectors of insects are very careful to have the locality and date with every specimen appreciating that the geographical and seasonal distribution of insects are questions of great importance. The data accumulated in this way is of very unequal value, because in some cases the absence of record indicates the absence of the species from a locality and in other cases may indicate the rarity of the insect. The biologic significance of an insect depends on its degree of abundance. The real importance of the subject will lie in accumulating data to show the part each species plays.

There are over 10,000 species of insects recorded in California. Of these not over 1000 are found in many collections or known from any large numbers of localities. In none of the 9000 is there sufficient data at hand or liable to be secured to assist in solving any of the problems of geographical distribution. Nor do any of them play any important part in biological problems, unless it be the problem connected with the maintenance of existence by rare species.

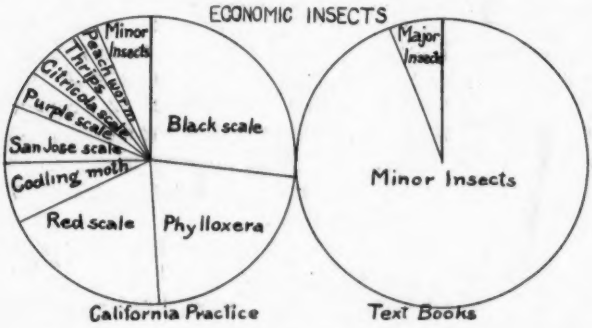
If only in the neighborhood of 10% of the insects contributed much to our knowledge of distribution it is probable that 1% includes all those whose abundance causes them to play an important part in the ecological relationships or in economics.

We must devise means of expressing the dominance of species perhaps in terms of their relative frequence of individuals or relative mass and for ecological purposes it might be better expressed in terms of food consumption as related to its distribution in regions, in special habitats or in seasons. The idea is that we have only touched some of the exterior details on the surface of the subject and must develop means of studying the quantitative significance of distribution in order to arrive at the real meaning of the subject.

But it will not be necessary to follow this idea through all the departments of entomology to the study of Physiology, Development or Life History, adaptations and the various other departments of ecological study. One will see at once that the same need of a definition of the elements of the subjects, their subdivision and classification until we can express differences quantitatively with quite rigorous accuracy will open the way to a new and loftier conception of our subject and in conclusion I wish to point out some of the changes this line of development is beginning to produce in economic entomology and particularly to the portion which might be called Horticultural Entomology.

*Economic Entomology* has gone through remarkable changes of viewpoint. Half a century ago the subject would have been defined as the study of injurious insects. After the remarkable series of discoveries in the seventies and eighties of our whole series of efficient insecticides, the thought of entomologists so changed that the subject might have been defined as treating of the methods of killing injurious insects. Now the emphasis

is shifting to the truer conception that economic entomology is the science treating of the methods of making money by the control of insects. The older entomologist devoted a great deal of time to life histories, parasites and predaceous insects. After really effective insecticides were discovered these so-called natural remedies were chiefly relegated to those injurious species not satisfactorily handled by real remedies and finally we are beginning to appreciate that even the knowledge of an effective way to kill an insect pest is not enough to bring it within the domains of a truly economic entomology, it is only those things we can do at a profit with which economic entomologists are, or should be, concerned.




This changing attitude does not yet find full expression in our books and, I am convinced, in our teaching. We are giving too much emphasis to minor matters. On the accompanying chart are given the relative economic importance of insects in California as based on the best means we have at hand of measuring this relationship, that of the money expended in control work. We spend about a million dollars a year in this work in California, divided approximately as shown in the chart. Some items may have only a temporary status in the rank shown, such as the Citricola scale and Thrips, but in the main features this chart will probably represent the situation for years to come. Our books on economic entomology give about 5% of their attention to the nine insects that constitute 95% of the control work.

This emphasizes in a striking manner the prominence we gave to the occasional and exceptional matters which will come to take more nearly their proper place when this tendency towards quantitative work has progressed further.

I trust while those present may not be ready to adopt all or any of the suggestions of this paper that the underlying idea will meet with your approbation and that perhaps some may be stimulated to take what is here urged as the future progressive work along the lines in which the trend of the science must proceed.

## PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

### California Summer Meeting.

The first session of the Entomological Society of America convened at the University of California, Berkeley, California, in room 113, Agricultural Hall, on August 9, at 10:30 A. M. The meeting was called to order by the Temporary Secretary, who, after a few preliminary remarks, suggested, that because of the absence of the President and the two Vice Presidents, a Temporary Chairman should be first elected. Professor C. W. Woodworth of the University of California, was accordingly nominated by Professor W. M. Wheeler, seconded by Professor A. L. Melander, and duly elected. Following this the Temporary Secretary read a number of invitations and communications, after which, there being no further business, the meeting adjourned until 2:00 P. M.

The second session was called to order by the Temporary Chairman and after the reading of a few announcements, proceeded with the regular program.

A. L. Melander, State College of Washington—The Pronunciation of Insect Names.

The discussion of Professor's Melander's paper was opened by Professor Woodworth and participated in by Dr. L. O. Howard, Mr. O. H. Swezey, Professor Melander, Mr. Killeen and Professor H. F. Wilson.

A. L. Melander, State College of Washington—The Review of the American Species of Scatopsidæ. Read by title.

W. M. Wheeler, Harvard University—On the Presence and Absence of Cocoons Among Ants, the Nest Spinning Habits of the Larvæ and the Significance of the Black Cocoons of Certain Australian Species.

A few remarks were made with regard to the paper by Dr. Wheeler, by Dr. L. O. Howard, who, on behalf of the Society, wished to compliment the author, by Mr. H. G. Champion, and by Dr. E. C. Van Dyke.

Professor A. J. Cook, State Horticultural Commissioner of California, extended an invitation to the members to visit the State Insectary, located at Sacramento and the Quarantine Station in San Francisco. The Society then adjourned, to meet on Tuesday at 10:00 A. M., at the same place.

The third session was called to order by the Temporary Chairman and the regular program resumed.

E. D. Ball, Utah Agricultural College—Some Special Adaptations to Arid Conditions Exhibited by Cercopidæ and Membracide.

This paper was discussed by the Temporary Chairman, Professor H. F. Wilson, Mr. E. P. Van Duzee, Mr. H. G. Champion and Dr. E. C. Van Dyke.

H. F. Wilson, Oregon Agricultural College—The Tribe Pterocomini, Family Aphididæ. Read by title with the addition of a few remarks.

J. Dewitz, Metz, Germany—Ueber die Gifte Pflanzenlause.

A translation of Dr. Dewitz's paper was presented by Professor W. M. Wheeler of Harvard University, under the title: "On the Poisons of Plant-Lice." The reading of this paper was followed by a general discussion of the paper and of plant-lice in general by Professor H. F. Wilson, Mr. Leroy Childs, Professor A. L. Melander, Mr. Swezey, Mr. E. H. Ehrhorn, and Mr. G. A. Coleman.

M. A. Yothers, State College of Washington—The Physiological Effects of Endoparasitism upon the Host Insect. Read by title.

M. A. Yothers, State College of Washington—Some New Insects of Importance in the Northwest. Read by title.

The Society then adjourned to meet on Wednesday, August 4th, at 2:00 P. M., at the Leland Stanford Junior University.

The fourth session, preceded by a cafeteria lunch, served on the Campus, was called to order by the Temporary Chairman, at 2:00 P. M., at the Leland Stanford Junior University and the following paper was presented:

Isabel McCracken, Leland Stanford Junior University—Notes on California Cynipidæ with Particular Reference to the Species *Diplolepis ambrosa* Full.

The paper was followed by a demonstration of material and breeding methods by Miss McCracken and discussed by the following: Professor Woodworth, Mr. Champion, Mr. Childs, Professor Lawrence Bruner, and Dr. E. C. Van Dyke.

An early adjournment was made in order to allow the members to attend the meetings of other scientific societies in session.

A large number of the members attended a banquet given on Wednesday evening at the Hotel Sutler, in San Francisco, by the Biological Society of America.

The fifth session was called to order by the Temporary Chairman, at the University of California, in room 212, of Agricultural Hall, on Thursday, August 5th, at 10:00 A. M. and the following papers were presented:

W. B. Herms, University of California—The Anopheline Mosquitoes of California, Distribution and Ecological Considerations.

This paper was discussed by Mr. Ehrhorn, Dr. McCracken, Dr. L. O. Howard, Professor C. P. Gillette, and Professor W. A. Riley.

James Zetek, Panama Canal Zone—The Reduction of Malaria by Reducing the Number of Malarial Mosquitoes within a House. Read by the Temporary Secretary.

Discussed by Professor Herms, Professor Bruner, Dr. Howard, Mr. Ehrhorn, Professor Woodworth, Dr. F. E. Blaisdell and Mr. Swezey.

F. C. Bishop, United States Bureau of Entomology—The Distribution and Abundance of the Ox Warbles (*Hypoderma lineata* and *H. bovis*) in the United States. Read by title.

The Society then adjourned until 2:00 P. M.

The sixth session was called to order by the Temporary Chairman and the following papers were presented:

E. P. Van Duzee, University of California—Priority in Family Names and Related Matters.

Discussed by Mr. H. L. Viereck and Dr. L. O. Howard.

E. C. Van Dyke, University of California—The Distribution of Insects in Western North America.

Discussed by Dr. L. O. Howard.

C. W. Woodworth, University of California—Quantitative Entomology.

Discussed by Mr. F. A. Varrelman.

Dr. L. O. Howard offered a resolution of thanks to the University of California and to Dr. E. C. Van Dyke for making arrangements for the meeting, which was seconded and carried, after which there being no further business, a permanent adjournment was taken.

EDWIN C. VAN DYKE,
*Temporary Secretary.*

## DATES OF ISSUE FOR 1915.

The following are dates of mailing for the ANNALS at the Post-office, Columbus, Ohio:

No. 1—April 20, 1915.
No. 2—July 2, 1915.
No. 3—October 11, 1915.

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